# SOMETHING ABOUT SUGAR

# SOMETHING ABOUT SUGAR

ITS HISTORY
GROWTH, MANUFACTURE AND
DISTRIBUTION

BY

GEORGE M. ROLPH

*Sugar*
*is nothing more nor less*
*than concentrated*
*sunshine*

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DEDICATION:

TO R. P. RITHET

## FOREWORD

*The purpose of this book is to tell in simple language "Something About Sugar." It gives a brief history of the commodity and its production in different parts of the world, and seeks to show, for the information, especially, of the layman and the pupil in school, the various steps by which sugar from cane and beets is prepared for the consumer.*

G. M. R.

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### *Growth, Manufacture and Distribution*

## Part II

## *History of the Industry*

# Part I

## *Growth, Manufacture and Distribution*

## WHAT SUGAR IS

AMONG the many varieties of sugar the most important are the sucroses and the glucoses. They form a natural group of substances, chiefly of vegetable origin. Chemically considered, all sugars are carbohydrates, that is to say, bodies composed of three elements: carbon, hydrogen and oxygen. Sucrose contains twelve atoms of carbon, twenty-two atoms of hydrogen and eleven atoms of oxygen.

Apart from sucrose, which is usually cane and beet sugar, the variety most generally met with is dextrose—one of the glucoses. It possesses less sweetness than sucrose and differs from the latter in chemical composition. As an example: dextrose is found in the raisin in small grains. It also occurs in other fruits and is the result of the inversion of sucrose.

Glucose enters largely into the manufacture of candy, being particularly necessary in the preparation of soft filling for creams, as a certain amount of it added to cane-sugar syrup prevents crystallization.

Sucrose is derived from sugar cane, maple sap, sorghum and the sugar beet. It is a solid, crystallizing in the form of monoclinic prisms, generally with hemihedral faces, which are colorless, transparent, have a sweet taste, a specific gravity of 1.6 and a melting point of about 320 degrees Fahrenheit. It is soluble in about one-half its weight in cold water, and in boiling water in almost all proportions. It is practically insoluble in alcohol, turpentine, ether, chloroform and similar fluids.

The crop of 1914-15 showed a world's production of 18,409,016 long tons of sugar, and in the chapters relating to the history of sugar will be found a statement setting forth the

amount produced by each country. The total was derived about one-half from cane and one-half from beets, produced as follows:

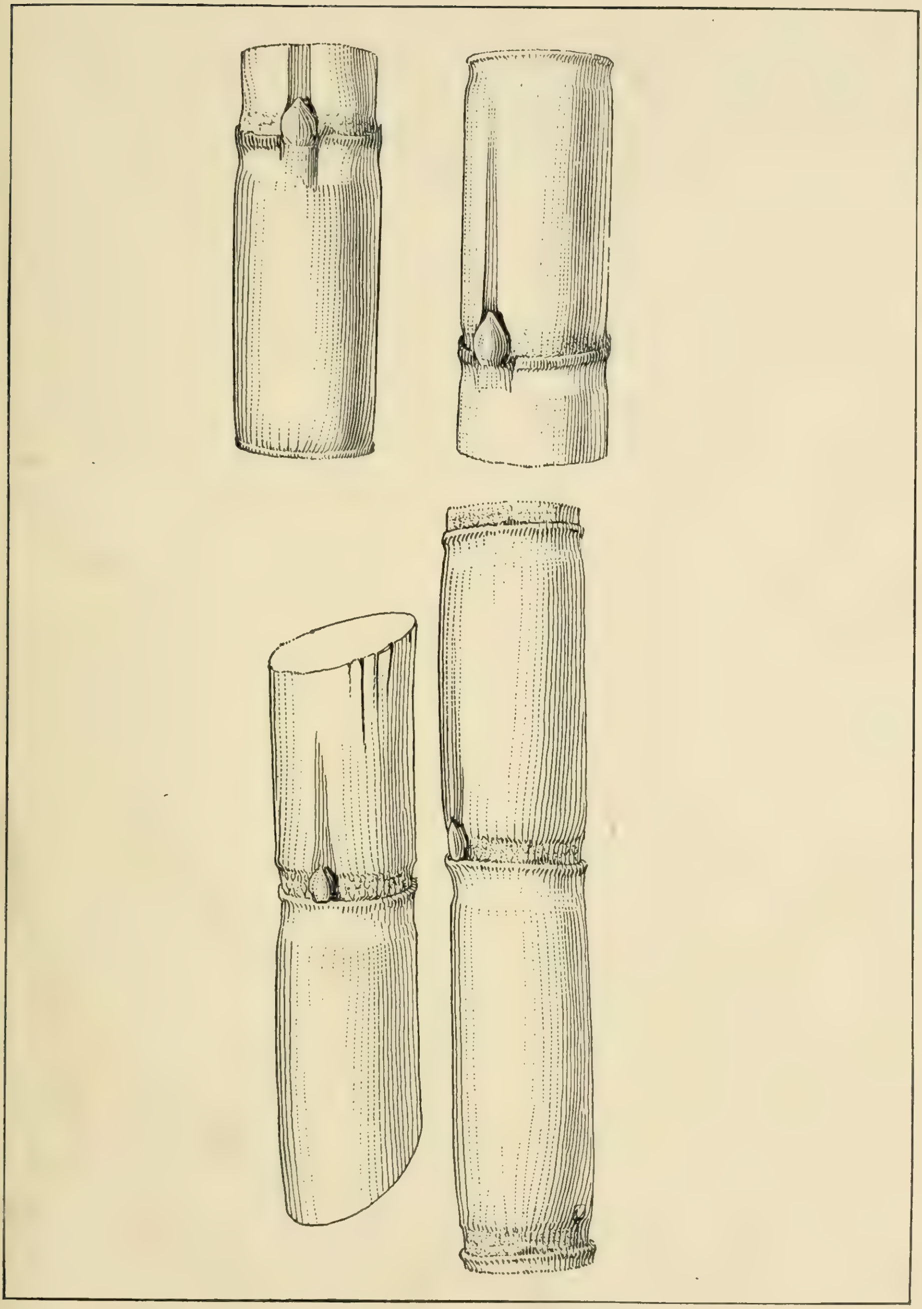
| | CANE | BEET |
|---|---|---|
| Total in America | 5,017,375 | 660,236 |
| " " Asia | 4,268,618 | |
| " " Australia and Polynesia | 348,408 | |
| " " Africa | 523,788 | |
| " " Europe | 7,376[1] | 7,583,215 |
| | 10,165,565 | 8,243,451 |

[1] Spain.

Sugar cane, described in botany as *Saccharum officinarum,* is a giant-stemmed perennial grass that grows from eight to twenty-four feet long. When ripe it produces at the top of its stalk a large feathery plume of flowers of a gray inflorescence called the "tassel," which is from two to four feet in length.

There are many kinds of cane, all of which are regarded as varieties of one species, although some botanists have raised a few to the rank of distinct species. The cultivated types are distinguished by the color of the internodes, yellow, red, purple or striped, and by other general characteristics.

The stem of the cane is solid, with joints at intervals of three to six inches. In diameter it ranges from one to two and a half inches, and is unbranched, bearing in its upper part numerous long, narrow grass-like leaves, arranged in two rows. The leaves spring from large sheaths around the joints, and have a more or less spreading blade from three to five feet in length and two inches or more in width. The pith, of open cellular structure, contains the sugary juice. The tops, which contain but little sugar, are not crushed, but are used for seed, as the plant germinates from the eyes, or buds, which grow on the



SUGAR CANE—SHOWING EYES OR BUDS

stem around the joints. Practically no cultivated cane is propagated from its seed. The roots that remain in the ground after the cane is harvested throw up fresh canes or ratoons for many seasons, after which replanting is necessary. Hawaiian growers do not count on ratoons for more than a few crops, whereas in Cuba this process can be repeated for many years.

As a rule, sugar cane consists of about eighty-eight per cent of juice and twelve per cent of fiber, the juice content varying from time to time, both as regards quality and amount. The quantity of the juice pressed from the cane determines the efficiency of the extraction, while quality is the main factor when the result of subsequent manufacture is under analysis.

It is difficult to arrive at a fair average of the composition of the juice of the cane, as it varies in different countries, on different plantations in the same country, and at different periods in any one year. The following is an approximation:

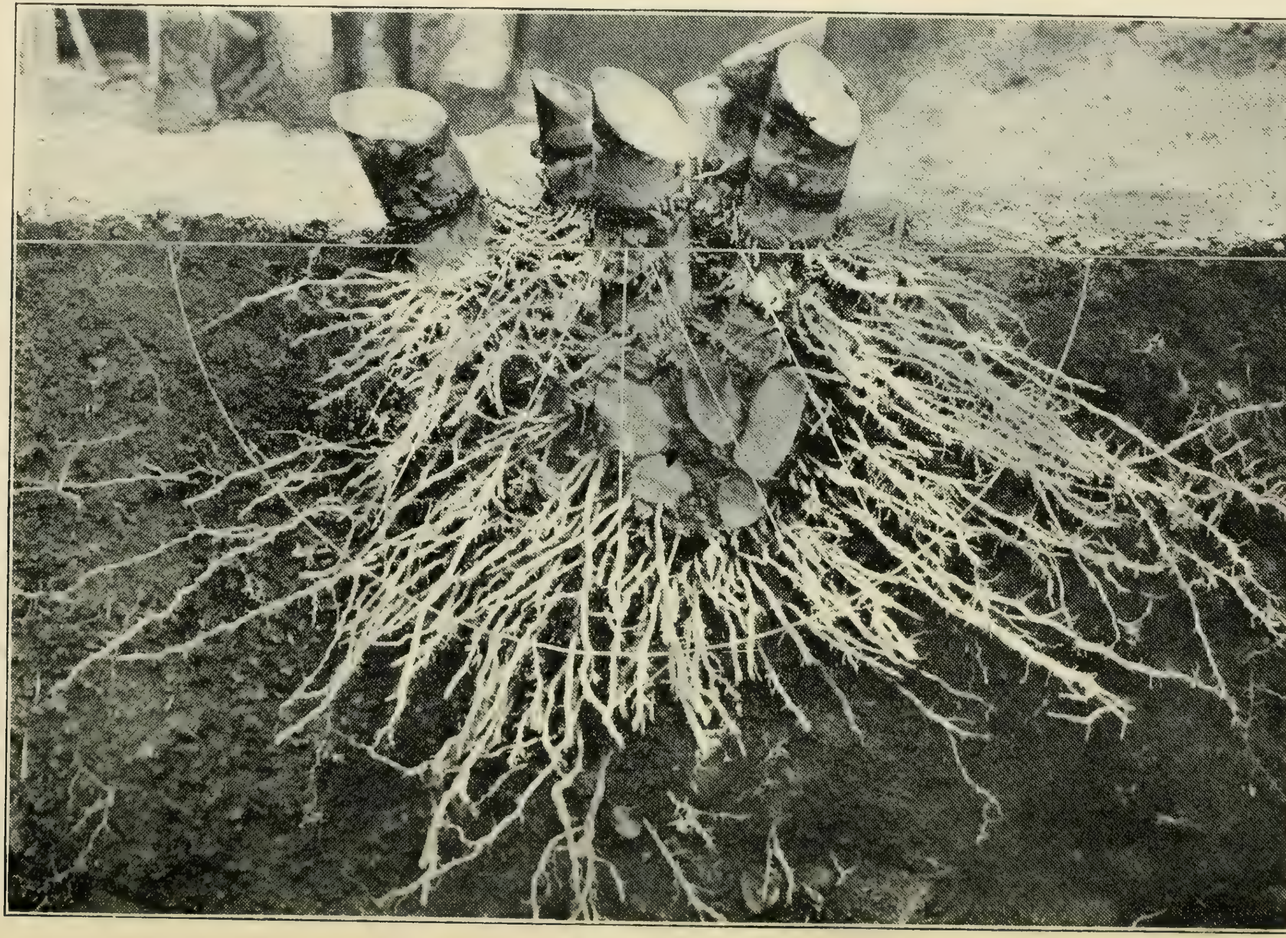
| | | |
|---|---|---|
| Water | 80.8 | per cent |
| Sugar | 16.4 | " " |
| Invert sugar | 1.98 | " " |
| Organic non-sugar | .54 | " " |
| Ash (mineral matter) | .28 | " " |

# THE GROWING OF SUGAR CANE

SUGAR CANE grows almost exclusively in the tropical belt, extending from twenty-two degrees north to twenty-two degrees south latitude, where the three essentials for its successful culture, viz., fertile soil, hot sunshine and plenty of moisture, are present. It flourishes in the islands of the Pacific ocean, particularly in the Hawaiian group, in Cuba, Mexico, Central America, the islands of the East and West Indies, Australia, China, India, along the shores of the China sea and the Indian ocean, and in certain parts of Africa and South America. In the low latitudes of the temperate zone it is grown with only fair success.

Owing to peculiar climatic conditions, sugar cane has been raised in southern Spain for generations, notwithstanding the fact that the provinces in which the sugar cane is grown lie, roughly speaking, between thirty-six degrees and thirty-eight degrees north latitude. The Gulf Stream is no doubt largely responsible for this phenomenon. The quantity of sugar produced in Spain, however, is small, the crop of 1914-15 amounting to less than 8000 tons.

Sugar cane thrives best in a moist, warm climate, with moderate intervals of dry, hot weather, and plenty of water for irrigation. It requires marly soil, free from saline ingredients. As a rule, it is raised on the lowlands, where the temperature is highest and where it is easy to bring water for irrigation. In Hawaii it takes eighteen months to ripen, and "tasseling" occurs about thirty days before it is ready to be cut. In Louisiana and Texas, because of the short seasons, cane is harvested in from nine to ten months from the time of sprouting, and, con-



ROOTS OF SUGAR CANE

JUNGLE-LIKE VEGETATION OF CANE FIELD

sequently, before it has attained maturity. In Cuba it is cut in twelve months, whether it is ripe or not.

As the scientific culture and manufacture of sugar is probably further advanced in the Hawaiian islands than in any other part of the world, a description of the industry as carried on there will serve to illustrate the intensive cultivation and scientific methods of the present day.

The Hawaiian islands are situated in the Pacific ocean, in latitude nineteen degrees to twenty-two degrees north and in longitude one hundred and fifty-four degrees to one hundred and sixty-one degrees west, and are free from the destructive hurricanes of the East and West Indies. They are of volcanic formation and, as a rule, their centers are mountainous, in some instances reaching an elevation of nearly fourteen thousand feet. During the ages, torrential rains carried volcanic ash from the mountains toward the sea, near which it was deposited, thus forming alluvial areas of vast richness around the circumference of the islands. Parts of some of the islands are fringed with coral reefs, barriers that retain the washings from the mountains. In these low-lying areas the soil is extraordinarily fertile, and it is on such ground that the most generous crops are raised.

The soft, warm trade winds that blow from the northeast become laden with moisture as they sweep over the ocean; when they strike the cold mountain peaks the moisture condenses immediately into copious rains. The precipitation in some places reaches the astounding total of three hundred inches per annum. The rain water is conserved and, when needed, is carried to the various plantations by immense irrigation ditches.

In this tropical region there is an abundance of sunshine, accompanied by humid heat, exactly the conditions needed. It required only man's ingenuity to utilize what nature so lavishly provided.

The commercial cultivation of sugar cane in these islands began about 1850, when a few hundred tons of raw sugar were produced, but the methods of husbandry and manufacture were crude. Time and experience worked great changes, until in 1914-15 the crop of raw sugar totaled 646,448 tons of 2000 pounds each.

For many years past the sugar planters have maintained in Honolulu an experimental station that is the marvel of the agricultural world. The bulletins issued by it are recognized as authoritative, and are read with interest in every sugar-producing country.

The most important features of the work carried on at this station are:

1. SOIL ANALYSIS

Skilled chemists examine the soils of the various plantations and, when occasion demands, advise the planter what necessary element is lacking, as well as how to obtain and apply it. A few years ago this branch of the work was considered highly important. Recently, however, the agriculturists have been depending more upon well-defined systems of experimentation. Each plantation has on its own lands plots of ground on which different methods of culture are tried and on which various kinds of fertilizer are used. Experiments are also made to determine the exact amount of water needed for irrigation. Particular attention is paid to seed cane, and a number of types of it are planted in order to obtain seed that will produce stalks that grow rapidly, yield a large tonnage per acre, contain a maximum amount of sugar, and have a high resistant power against disease and insect pests. The success attending this practical experimental work is such that soil analysis is being relegated to second place.

2. ENTOMOLOGY

A staff of trained experts assiduously study the insect life and eagerly watch for harmful, troublesome pests, which in the past

have wrought great damage. It is their duty to find the means of eliminating these pests, and this they usually accomplish through the skillful use of insect parasites.

### 3. PATHOLOGY

The pathologists attached to the station supplement the scientific labors of the chemists and the entomologists by prescribing for any disease that may attack the cane. Plant life is subject to as many ills as the human family, and the work of these specialists in restoring health to ailing cane is of the highest importance.

To fully illustrate the character and scope of their work, a particular instance for each department may be cited:

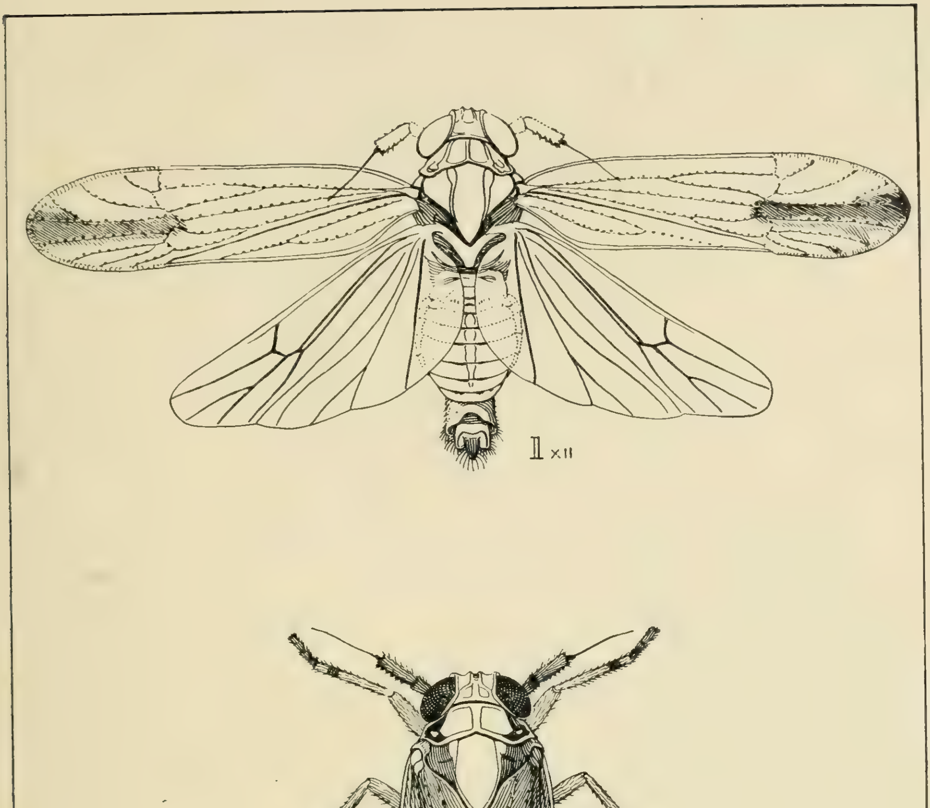
A certain planter found that the amount of sugar obtained from his cane was decreasing yearly, though he could see no good reason for it. The land looked right; he ploughed deeply, harrowed well, kept the weeds down, gave the cane plenty of water, could find no reason to complain of climatic conditions, but still did not get satisfactory results. Finally the head of the experimental station was consulted and an agricultural chemist was sent to the plantation. This chemist, after careful investigation, took samples of the soil from various parts of the land; these were analyzed and the source of the trouble was found to be the lack of potash. Just here it may be explained that when the same crop is taken from the land many years in succession, without adequate fertilization, some of the essential properties of the soil become exhausted. Speaking generally, these are lime, soda, potash, phosphates and nitrogen. In this particular instance, as has been said, the land had been gradually drained of its potash. The experimental station recommended the planter to scatter a certain fertilizer over his fields. This advice was followed and the next crop showed remarkable improvement, the yield of cane and sugar per acre being greater than ever before.

At one time the sugar industry of the Hawaiian islands was threatened with annihilation by a little insect called the "leaf-hopper." The harm done by this pest was so enormous that one plantation having an average yearly crop of 19,000 tons was so severely affected that the yield dropped from 19,000 to 12,000, and then to 3000 tons in three successive crops. All the plantations on the islands suffered to a greater or lesser extent, and the entire sugar industry of Hawaii was jeopardized.

The hoppers punctured the stalks and leaves of the young cane, and in the holes thus formed laid their eggs by thousands. When the young hoppers hatched out, they fed on the juices in the stalk and in the leaves, thus destroying the leaves and depriving the cane of its protection and principal means of absorbing nourishment from the air.

As soon as the leaf-hopper by its ravages made itself known in the islands, the entomologists were consulted, and they were confronted with the task of studying the life and habits of the hopper for the purpose of finding, if possible, some other insects that would attack and exterminate it. It is well known to entomologists that every insect pest has natural enemies; the vital question in this case was—what were the natural enemies of the leaf-hopper and where were they to be found? Obviously, too, the problem was to discover insectivorous enemies that would not themselves attack the cane after they had destroyed the hopper.

After careful investigation it was concluded that the leaf-hopper had been introduced in Hawaii in new varieties of seed cane imported from Australia, and, as the hopper was not doing material damage on the plantations in Australia, the inference was that it must be controlled there by its natural enemy. The chief of the Department of Entomology was sent to London. There in the archives of the British Museum he found a full description of the leaf-hopper and that its native habitat was




LEAF-HOPPER (GREATLY MAGNIFIED)

SUGAR CANE

Queensland, Australia. On his return to Hawaii, entomologists were sent to Australia and the search for the enemy of the hopper began.

For weeks the entomologists virtually lived in the cane fields, undergoing extreme privations, but at last their faithfulness was crowned with success. Several species of parasites that kept the Queensland leaf-hopper in check were discovered, and later on more were found in the islands of Fiji. These tiny creatures as a rule were invisible to the naked eye and could only be seen with the aid of a powerful magnifying glass. All of these insects were parasites either of the leaf-hopper or its eggs. Two of them were particularly efficacious. One, quicker in movement than the hopper, caught it unawares and attached itself to the hopper's body much in the same way that a mosquito does to a human being. After catching it, the parasite would sting the hopper and lay an egg in its body. In a few days a young parasite was hatched from the egg, and so ravenous was this young insect that it devoured the hopper in a short time and then sought a fresh victim in which to lay its eggs.

The other insect was even more effective. It liked the hoppers' eggs and for a long time found plenty in Hawaii to stay its appetite. As soon as the leaf-hopper laid its eggs in the cane, this particular insect would appear and lay its eggs in the eggs of the leaf-hopper. When the little enemies hatched out, they fed on the hoppers' eggs and in turn laid their eggs in the eggs of the hopper. It came to pass that the hoppers, attacked by the parasite on the one hand and by the enemy on the other, rapidly dwindled in number until only a few remained, and these not enough to do material damage. As the hoppers and their eggs diminished, so did the parasite and the enemy, for the latter could live on insect food only.

How the scientists collected these tiny animalcules, kept them alive, transported them thousands of miles across the

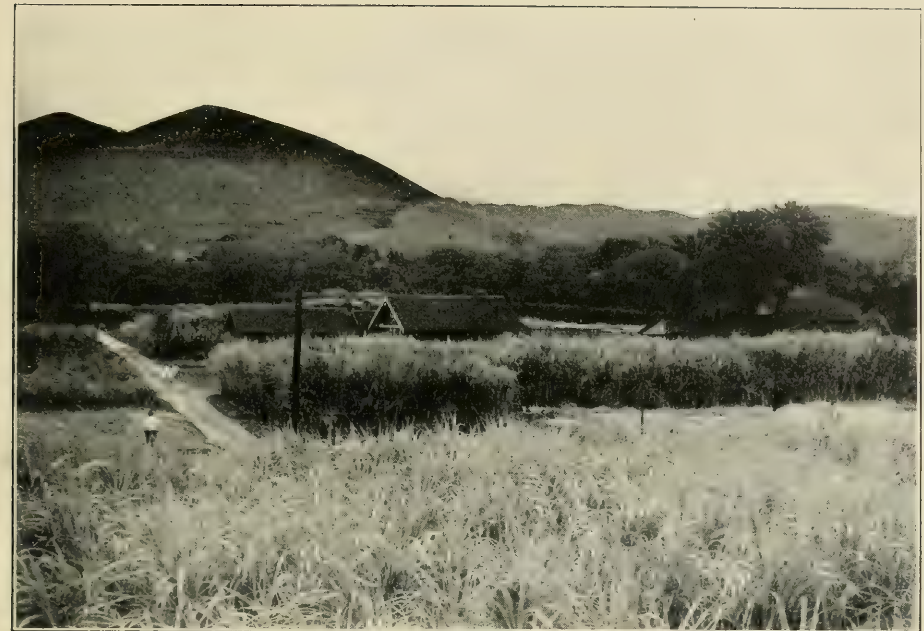
ocean, bred them in Hawaii and saved the Hawaiian sugar industry, reads like a romance.

The study of entomology is extremely interesting and the every-day business man rarely understands its importance. The finding, breeding and distribution of parasites of insect pests vitally affects the world's food supply. The entomological name of the leaf-hopper family is *Hemiptera*, and Dr. Sharp, an authority on the subject, has said: "There is probably no order of insects that is so directly connected with the welfare of the human race as the hemiptera; indeed if anything were to exterminate the enemies of hemiptera, we ourselves should probably be starved in the course of a few months."

It has been estimated by competent authority that the damage done in the world each year by the hemiptera, in spite of all their parasites, is conservatively $600,000,000. Were it not for the parasites, it would only be a year or two at most before every green leaf and spear of grass would disappear from the face of the earth. The direct influence of the practical application of this science to the production of sugar is readily apparent.

Pathology is almost equally important. In former years when cane failed to grow strong and sturdy and did not yield much sugar, the planter usually attributed the difficulty either to lack of water, poor soil, cool weather, too much rain or insufficient cultivation of the field by his manager, when in fact the trouble was due to none of these causes. He would personally oversee the operations of the following year, but with no better results.

When the roots of the cane became matted, stuck together and turned black, when a thick gum exuded from the stalk and leaves, preventing the plant from drawing proper nourishment from the air, it was thought that these troubles arose from climatic or local conditions, while in reality the plant was sick and needed a doctor. Today, under the new regime, whenever the



EXPERIMENT STATION

PLANTATION SCENE IN HAWAII—LIGHT-COLORED FOLIAGE IS SUGAR CANE

plant shows any symptoms of ill-health, the pathologists are called in to eradicate the disease by scientific treatment.

Insect pests and plant diseases are generally brought into a country through planters sending to other cane-raising countries for new varieties of cane for seeding purposes that they think may produce more sugar than their own. Great trouble and heavy loss have been occasioned in this way and, as a consequence, the United States government has established a strict quarantine, allowing plant life to be landed only after rigid examination and when it is clear that no danger exists.

Another example of the work of the entomologists may be of interest:

During the visit of a well-known Hawaiian to Mexico many years ago, his attention was attracted by a beautiful shrub that he thought would make a splendid hedge around his home. It grew about five feet in height and its foliage was of a rich green, with a brown, red and yellow flower. The slips he brought to Honolulu thrived wonderfully and cuttings of the plant were taken to the other islands for a like purpose. Wherever planted it grew amazingly fast. It quickly spread over the hillsides and became so dense that cattle could not penetrate the thickets formed by it. It made valueless large areas of land that formerly had been used for the pasturing of cattle and plantation stock, and reduced the grazing area at an alarming rate. Land that adjoined the plantations and that in the course of time became needed for plantation purposes was also overrun by it.

The curtailment of the grazing lands and the increased cost of clearing were so great that the entomologists were finally sent for and asked if they could not eradicate the trouble. After a careful investigation they went to Mexico, whence the lantana, as the shrub is called, had come. On their return journey they brought back with them a fly. The fly laid its eggs in the

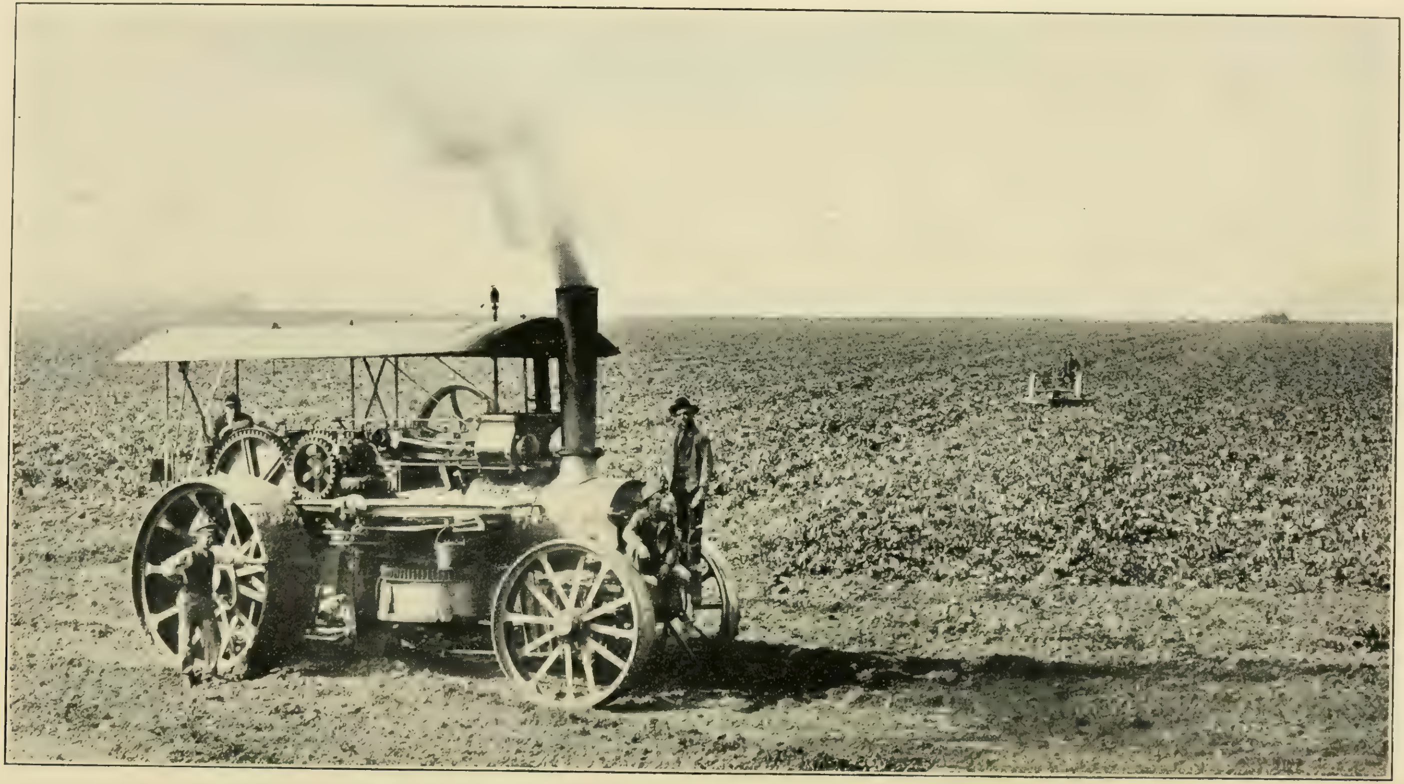
bud of the lantana, and when the young flies were hatched they fed upon the lantana seeds. The flies multiplied rapidly and soon made away with the seeds, thus preventing the shrub from spreading any further. When it was once cleared from the land or the plantation it did not reappear.

These illustrations demonstrate the fact that the culture of sugar cane involves a constant struggle between science and unrestrained nature.

As a rule, Hawaiian sugar plantations are located close to the seacoast, between it and the base of the mountains. The lands slope gently toward the sea, thus insuring good drainage and easy application of water for irrigation. Most of the cane is grown on land less than five hundred feet above sea-level, although in a few rare instances it is cultivated at an elevation as great as three thousand feet. Parts of the leeward side of the islands, where it is extremely dry and hot, and where the cane thrives best, depend entirely on irrigation, the water being brought to the plantations by ditches or pumped from wells. On the windward side of the island of Hawaii, where the rainfall is abundant, irrigation is unnecessary except during very dry periods.

In cultivating, the ground is turned with steam ploughs to depths up to twenty-four inches. These ploughs are operated by powerful engines that work in pairs, one on each side of a field, usually from one thousand to fifteen hundred feet apart. One engine pulls a gang-plough across the field and the other draws it back. By this method the rich soil is thoroughly loosened and a wonderful vegetable growth results. Ordinarily in California the farmer ploughs only from four to six inches deep.

After the lands are ploughed and harrowed and all the weeds turned under, double mould-board ploughs are used to make the furrows in which the seed is planted. The furrows are not like those made for planting potatoes, but are about five feet apart



STEAM PLOUGH

PLANTING CANE

and eighteen inches deep, each furrow and hill being symmetrical. They follow the contour of the land so that the irrigation water will fill the furrow and remain there until it is absorbed by the soil and penetrates to the cane roots. At regular intervals of about thirty-five feet, lateral ditches are cut, from which there is an entrance into every furrow. These lateral ditches deliver the water from the main ditches to the various parts of the fields. The land is now ready for the seed.

Meanwhile, the harvesting of the ripened cane in other fields is going on. As the laborers cut the cane, they top it, that is to say, they cut off about twelve inches of the upper part of the solid stalk. Sugar cane resembles bamboo, in that it is cylindrical in shape and divided every few inches into sections by rings or joints. In every joint there is a bud or eye, from which a shoot of cane will sprout, if properly planted in the ground and watered.

These tops, always cut from untasseled cane, contain very little sugar. They are carried to the newly prepared field and placed in rows in the furrows, end to end, lengthwise, the ends overlapping a trifle in order to guard against blank spaces in the growing cane. They are then covered, according to the season, with one to one and a half inches of earth, and the water is turned in until the furrow contains from three to four inches of water. Between six and ten days afterward, the little green cane shoots appear above the ground. From this time forward continuous irrigation and cultivation, together with proper fertilization, are required until the cane matures.

Planting usually begins in March and continues until September, sometimes later, and the cane ripens one year from the following December.

Growing cane should be watered every seven days, and the amount of water used for this purpose is enormous. For example: a plantation producing thirty-five thousand tons of sugar

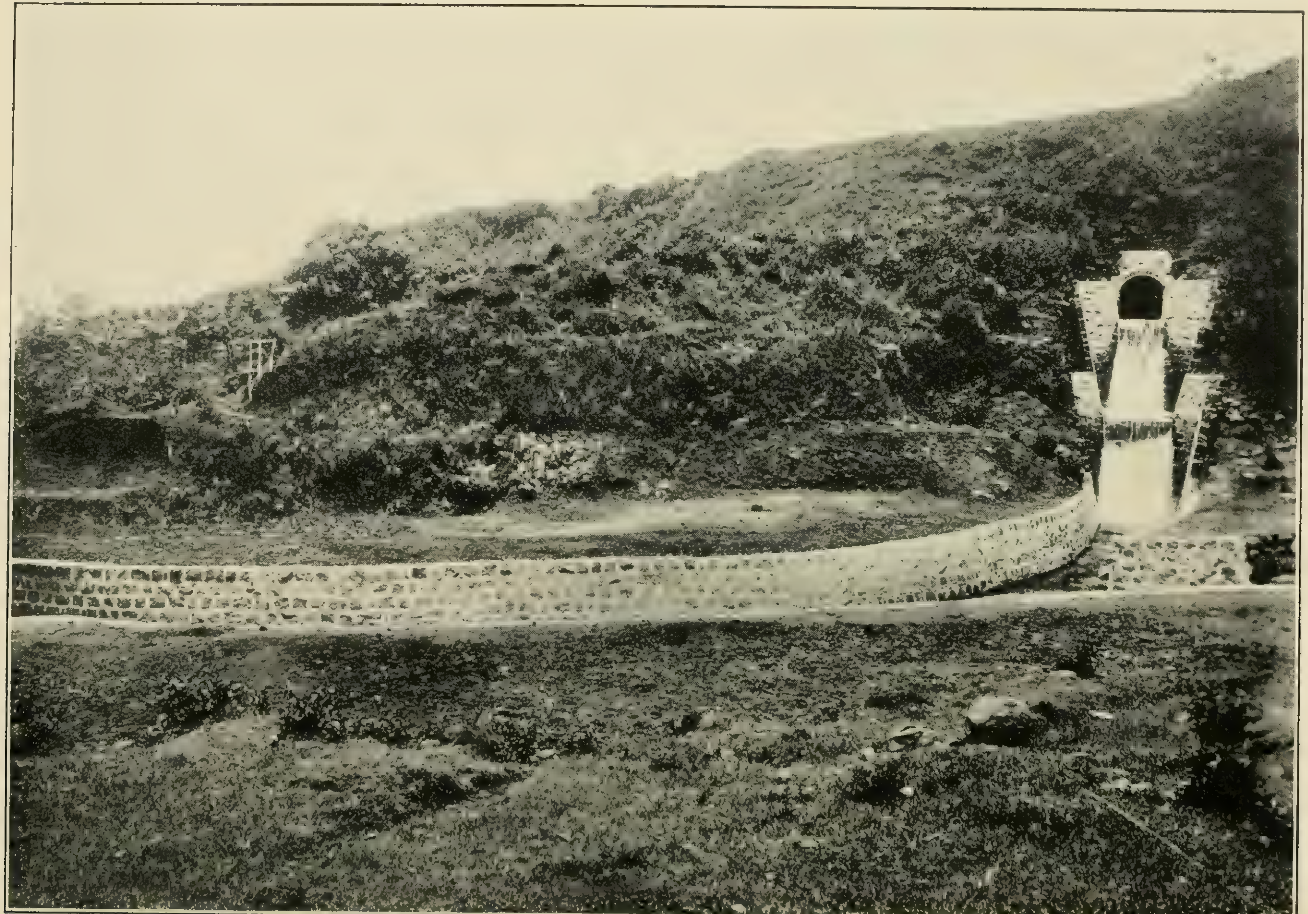
per annum needs twice as much water per day as the city of San Francisco.

The appearance of growing cane is much like that of Indian corn. The whole field area is covered with a dense, jungle-like vegetation of brilliant green. The leaves are long and narrow and hang in graceful curves. The cane grows so thick that it is almost impossible to crawl through it, and so seldom do the sun's rays penetrate to the ground that rapid evaporation of the irrigation water cannot take place, hence the cane gets the full benefit of the moisture.

In certain varieties of cane, the great weight of the juice in the stalks causes them to bend, droop and take fantastic shapes. Sometimes they lie on the ground with the ends turned upward, and in fields where the stalks grow to a length of twenty-four feet, the average height of the tops above the ground is not over twelve feet. In other kinds the stalks stand straight up to a height of from eight to fourteen feet.

The production of cane per acre varies in different countries and in different parts of the same country, according to the character of the soil, climatic conditions, care and attention, use of fertilizer and amount of rainfall or irrigation. In Hawaii it ranges from twenty to eighty-five tons, and the amount of sugar obtained per acre runs from two and one-half tons to twelve tons, the average being about five tons.

Broadly speaking, lack of a normal amount of cane per acre, lack of sugar in the cane, or the prevalence of disease, is primarily due to an unsanitary or unsuitable condition of the soil. This can usually be corrected by proper cultural methods, such as adequate aeration of the soil, the turning under of the cane tops and leaves, application of lime and suitable combinations of fertilizing ingredients. Fundamentally, cane requires a well-aerated, moist, alkaline soil and a fertilizer in which the nitrogen content is high and in excess of the potash and phosphoric



IRRIGATION DITCH—SHOWING TUNNEL.

IRRIGATION DITCH

acid. It is found that nitrate of soda, when applied alone or in combination with potash and phosphoric acid, produces a very strong growth. The proper sanitation of the soil tends to promote the beneficial bacterial action so essential to the growth of the cane.

In December and January the cane tassels or flowers, which indicates that it has about reached maturity and is ready for cutting. Thenceforward very little irrigating is done, as additional water applied at this time might retard ripening, which would mean a reduced amount of sugar stored up in the cane.

It is interesting to note that while the cane is growing and in an unripe state, there is no discernible sucrose or pure sugar in it. As the ripening process goes on, the content of the cane juice is changed by the action of the sun's rays, and the amount of sucrose as determined by polariscopic test shows when the time for harvesting is at hand. Nature's operation in thus changing glucose or invert sugar into sucrose or pure sugar cannot be accomplished by any human means.

The harvesting then begins and continues until the end of July or August. Usually the field is set on fire before cutting. On account of the great amount of moisture or juice in the cane, the stalks do not burn, but the leaves are thoroughly consumed. This operation eliminates a good deal of leaf material that is not only useless, but which, if sent to the mill, would increase the cost of crushing, besides absorbing a certain quantity of the juice expressed from the cane.

Formerly men stripped the leaves from the cane in the fields, but it was a difficult matter to accomplish such work, and the cost was heavy. An accident changed the method of doing this work. A field took fire and it was found that while all the leaves were consumed, little or no damage was done to the stalks provided they were cut promptly and sent to the mill to be crushed. The practice of burning has since become general, although the

advisability of continuing it is now being given very careful study.

Burning eliminates the arduous labor of stripping, and no doubt does away with many harmful insects and fungi, but at the same time it destroys the enemies and parasites of these insects and this loss is severely felt. Another disadvantage of burning is that the nitrogen contained in the cane leaves is liberated and not returned to the soil as would be the case if the leaves were stripped and ploughed under. In the latter case the leaves rot rapidly, add humus to the soil, help aeration, and improve the sanitary condition, all of which tends to increase the yield of cane per acre. From recent experience it is not improbable that burning will be discontinued in the near future.

As soon as the field is ready, whether burned or not, the laborers go in to cut the cane. A long, heavy knife is used. The cutter grasps the stalk and drives the knife into it, severing it just at the ground. He then tops it, that is, he cuts off the upper part that contains no sugar, and, to aid in subsequent handling, the long stalks are cut into convenient lengths.

As the burning destroys the eyes or buds, certain fields are cut and topped for seed before the burning takes place.

There are two general methods of transporting the cane to the mills. One is by rail and the other by flumes. On the irrigated plantations where water is never overplentiful, railroad tracks and locomotives are invariably employed, while on the non-irrigated plantations, located in districts where there are copious annual rains, V-shaped flumes are extensively used. In some cases a combination of both systems is adopted to advantage. From the upper lands where it is difficult to construct railroads, the cane is flumed to a convenient point on the railroad system, at a lower elevation, and delivered into cars, while the water is conducted into ditches and used for irrigating the lower cane lands.

YOUNG SUGAR CANE

RIPE SUGAR CANE—SHOWING TASSELS

In the case of rail transportation, paths one hundred and fifty feet apart are cut through the fields so that temporary railroad tracks may be laid and cars run in and loaded on these tracks. The whole field is then cut in the same way and the work continued until the entire crop is harvested.

The loaders follow up the cutters. These men lay a strap on the ground and pile the stalks on the strap until they have a bundle of cane weighing from seventy-five to one hundred pounds. With a dexterity born of long practice, they sling a bundle upon their shoulders and carry it up an inclined runway to a railroad car not over seventy-five feet away and dump it on the car. The cutting and loading are usually done by contract, at so much per ton, and it is remarkable how proficient the men become.

When flumes are used exclusively, much the same methods are adopted. Paths are cut through the fields and in these paths are placed the flumes which, like the temporary railroad tracks, are moved from time to time as necessity demands. The mill is located at the lowest point on the plantation and the flumes are placed so as to insure a good grade from the cane fields on the uplands to the mill below. The flumes are either carried on low trestles or run along the ground, but always at a height which enables the laborers to throw the cane into them conveniently.

Water is turned into the upper end of the flume and, rushing rapidly down, carries or floats the cane to the mill. Cane is flumed in this way for distances up to seven miles at low cost and with satisfactory results.

The cars when loaded in the fields are made up into trains and hauled by locomotives to the mill, which is generally located about the center of the plantation, or at a point where most of the cane can be delivered on a downward grade. Each car is carefully weighed on a track scale and the exact quantity of its load of cane is ascertained and recorded.

For years past the planters have been offering large rewards for the invention of a machine to cut and load the cane, but the old hand method is still employed, although some experimental loading machines are meeting with more or less success, but none are in common use.

The problems involved in cutting cane by machinery seem insurmountable, and, while many devices have been tried, not one has proved successful.

After the cane is cut the first time, ploughs are sent through the fields and a furrow is ploughed along each side of the stubs of the cane which are left in place. This ploughing opens up the ground, aerates the soil, and affords the irrigating or rain water a means of easy access to the cane roots. The water tenders follow up the ploughs and the furrows are filled with water, which is gradually absorbed by the old cane roots left in the ground. In time new sprouts spring up from buds on the old stalks of the cane and another growth begins. The second crop is called "first ratoons" and, when cultivated for a single year only, it is designated "short ratoons." As a rule it does not yield as much sugar as plant cane, but the saving in seed, in the preparation of the fields and in other labor frequently makes up for the reduced amount of sugar. If allowed to grow for two years, as is generally the case, it is called "long ratoons" and produces proportionately more sugar. In the past a very large percentage of the Hawaiian crop was planted with fresh seed every year and but a small percentage ratooned. Nowadays, however, the tendency is to ratoon the crop as long as the yield justifies, which in many cases is from three to four times. In Cuba the cane when once planted is ratooned for many years.

There have been specific instances in Hawaii where ratoons that have been allowed to grow for two years (long ratoons) have shown a better yield than the first planting. According to the best information, this is due to the presence of poisonous

CUTTING CANE

LOADING CANE

matter in the ground, turned up for the first time at the first planting.

The object of all the ploughing, weeding, cultivating, fertilizing and irrigating, is to produce a large number of strong, sturdy stalks of cane, yielding a maximum amount of sugar. The sugar is contained in solution in the sap or juice and the amount can be materially increased by due care and attention.

As some of the elements which form the plant are absorbed from the air through the leaves, favorable climatic conditions are essential to its full growth and development. Proper fertilizers must be added to the soil, and water applied regularly and in sufficient quantity.

Commercial fertilizers are used in Hawaii probably to a greater extent than in any other country in the world. It is quite common for plantations to use half a ton of fertilizer per acre per crop, and at times as much as two thousand pounds per acre. The yearly fertilizer cost per acre will probably average twenty-five dollars.

As it takes eighteen months for a crop to mature in Hawaii, it will readily be seen that the plantation area must be at least double that used for any one crop. While one crop is being harvested, another crop is in the ground growing. As soon as the cane is cut, the lands are immediately prepared for replanting or ratooning, as the case may be. During certain periods each year, usually in June and July, a visitor on an Hawaiian plantation can see one crop growing, one being harvested and one being planted.

From the foregoing it will be seen that the harvesting begins in December and ends in July or August. The planting begins from March to June and usually ends in September, according to plantation conditions and whether or not the land is irrigated.

# THE MANUFACTURE OF RAW SUGAR

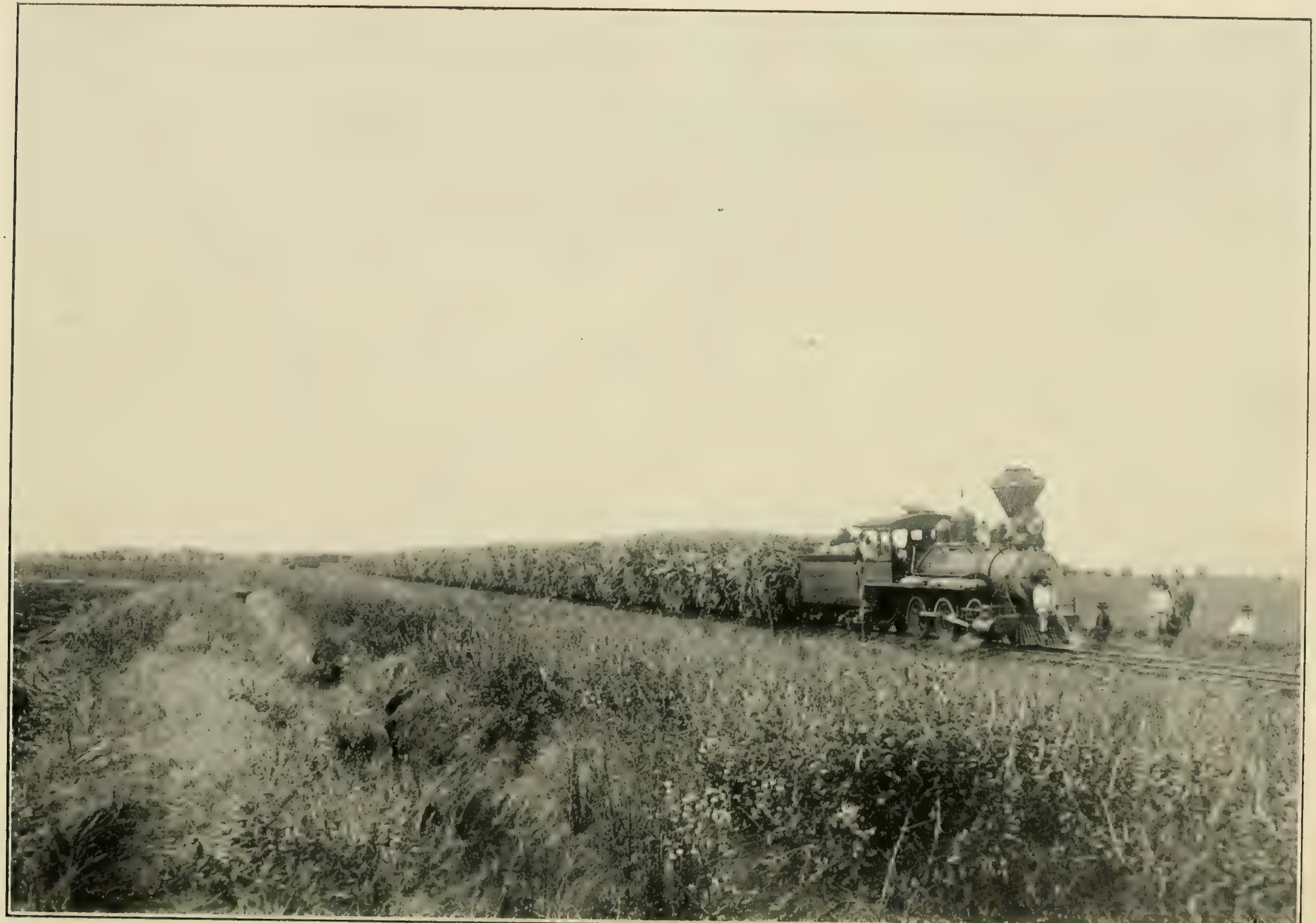
THE details of the manufacture of raw sugar from cane and of sugar from beet roots differ, but there are several processes common to both. The operations necessary for making raw cane sugar are as follows:

1. The extraction of the juice.
2. The purification of the juice.
3. The evaporation of the juice to syrup point.
4. The concentration and crystallization of the syrup.
5. The preparation of the crystals or grains for the market by separating them from the molasses.

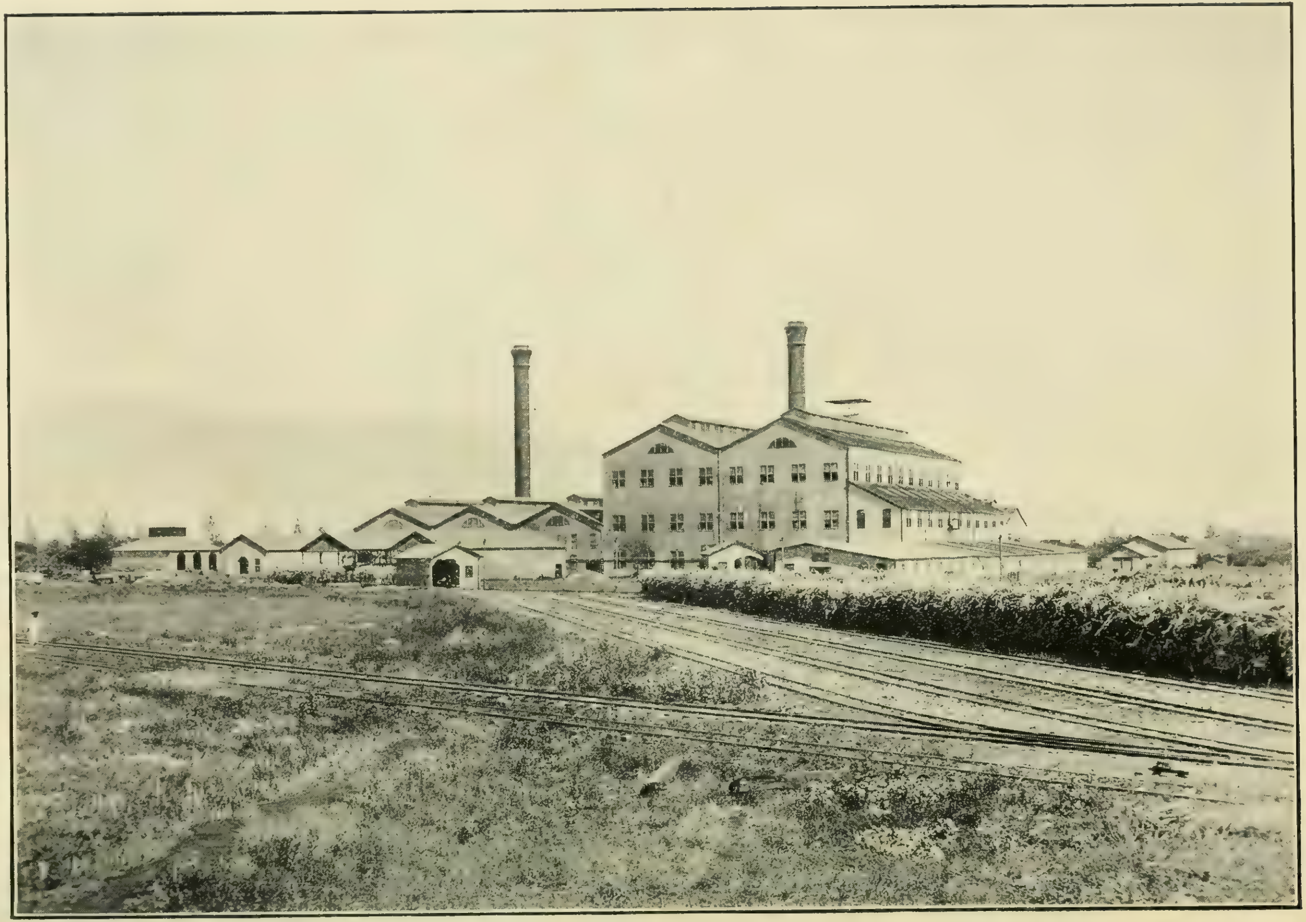
Every mill has an extensive laboratory where skilled chemists are constantly engaged in sampling and analyzing cane, raw juices, syrups, sugars and molasses. In fact the chemical work is a most important feature in the raw-sugar house, beet-sugar factory or refinery. The superintendent should be an expert chemist, as the proper recovery of the sugar from the cane and beet juices is wholly dependent upon the technical control of manufacturing processes.

### EXTRACTION

After passing the scales, the cars containing the cane are switched alongside the carrier which feeds the cane into the mills. Before the cane is unloaded, however, samples are taken from each car and sent to the laboratory, where they are carefully analyzed. The amount of sugar present is ascertained, as well as the quantity and quality of the juice in the cane. It is, however, impossible to get a fair average sample of the cane in this way, and therefore the efficiency of the mill work is deter-



TRAIN-LOAD OF CANE READY FOR THE MILL.



A MODERN MILL

mined on the basis of an analysis of the juice and the fiber after it has passed through the crushers.

The carrier just referred to is a wide slat conveyor, running alongside the railroad tracks in the yards to a point directly over the first set of crushers. The cane is taken from the cars by a mechanical unloader, the arms of which reach out and with distended fingers pull the cane stalks off and land them on the slow-moving carrier, which takes them onward and upward to the crusher.

The crusher consists of two large rolls, with immense interlocking, corrugated teeth on the circumference of each. These rolls are set close together, and the cane passing through is broken into short pieces and matted to an even layer. The juice squeezed out by this preliminary crushing runs through a metal trough into a large receptacle known as the juice tank.

From the crusher the mat of cane passes to the mills proper. These mills consist of from nine to eighteen rolls, about thirty-four inches in diameter and seventy-eight inches long, arranged in groups of three, set in the form of an isosceles triangle, one above and two below, one set following the other in a direct line. The lower rolls are parted enough to allow the expressed juice to fall through them, while the half-crushed cane is carried over by means of an iron bar called the returner. The faces of the rolls are more or less roughened, or grooved, so as to draw the cane through and give a better crushing action. They are turned slowly by powerful engines, which transmit the power to each set of rolls through a system of gears. The rolls are forced together by hydraulic rams exerting a pressure of from four hundred to six hundred tons. It is this tremendous pressure that squeezes the sugar-bearing juice out of the cane.

From the crusher the matted cane passes through the first set of rolls, where a large percentage of the remaining juice is liberated. This is caught in a metal trough and, after passing over

a fine screen to remove the small pieces of cane, runs to the juice tank. The cane passes through the second set of rolls, thence to the third set, and so on to the end of the mill. In front of the last set of rolls, hot water is sprayed on the cane to soften the fiber and dilute the remaining juice, thus aiding the final extraction. The adding of hot water is termed *maceration.* By the time the cane has passed through the last set of rolls, all the economically recoverable juice is out of it and delivered into the juice tank, with the exception of the juice and maceration water from the last set of rolls, which is always returned to the preceding set of rolls for maceration purposes. The juice or maceration water coming from the last set of rolls contains very little sugar, and the object is to secure greater concentration by using it for double maceration instead of adding that much additional water which would have to be evaporated later on in the process.

In well-designed, modern mills, with cane carrying not over twelve per cent of fiber, more than ninety-eight per cent of the sugar in the cane is extracted, the remainder being left in the fiber. This is almost perfection today. What it will be tomorrow no one can say.

The fibrous, woody part of the cane, or bagasse as it is called, is comparatively dry as it leaves the last rolls. It is conveyed from the mills to the boiler house on a wide slat conveyor, and fed directly into the furnaces under the boilers that generate the steam for power and boiling purposes. A modern raw-sugar mill requires practically no other fuel than that obtained as a by-product from the crushing of the cane.

The boiler plant is usually of large capacity, as a great deal of steam is required to drive the engines that run the crusher, the rolls, the electric lighting system, the pumps and other machinery. Besides, a large amount is needed to evaporate the water in the juice and to boil and dry the sugar. The ashes from

CANE CARRIER AND MECHANICAL UNLOADER

ANOTHER TYPE OF CANE UNLOADER

the furnaces are returned to the fields as fertilizer, so that very little is lost.

### PURIFICATION

The juice as it comes from the mills contains impurities such as dirt from the fields, small pieces of cane stalks and other foreign matter, besides salts, gum, wax and albumen. It is necessary to remove as many of these substances as possible, and this is where the chemist's work begins.

So long as the juice is confined in the living cells of the cane it does not quickly ferment, but when liberated it rapidly undergoes such change. Therefore no time is lost in arresting this action. The juice is pumped to the top floor of the mill and there a solution of milk of lime is added in sufficient proportions to neutralize the acidity. The mixture is then heated in closed tanks under pressure to 215 degrees Fahrenheit. The heat causes the lime to combine rapidly with the gums and salts in the juice, and the albumen to coagulate.

The hot juice is then run into large settling tanks, where the insoluble solids and the albumen sink to the bottom, carrying with them vegetable and other matter suspended in the juice. Certain foreign substances of light specific gravity float to the surface in the form of scum.

After settling for a time the clear juice is drawn off and the scum, mud and cloudy liquor left in the tank. As a vast amount of liquor must be handled every hour, it is not practicable to have tank capacity great enough to admit of the liquor standing a sufficient length of time for every particle of foreign matter to settle, so as an adjunct to the settling tank, filters are used. These are cylindrical iron tanks, packed tightly with ordinary wood fiber, known as excelsior. The juice is conducted to these filters, and as it percolates through the excelsior, practically all of the remaining foreign matter is caught and retained in the fiber. The clear juice is then run to the receiving

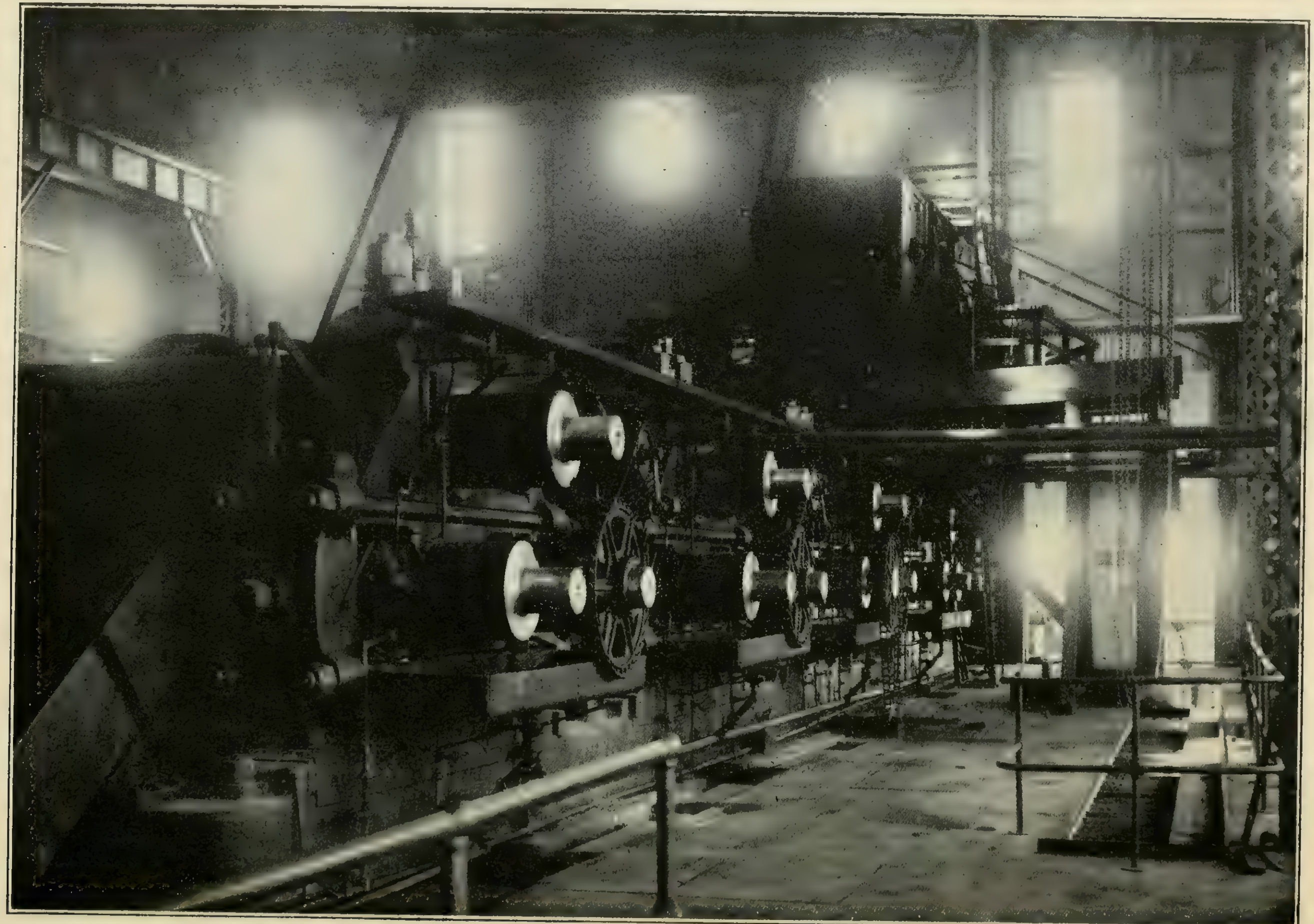
tanks for the evaporators and the mud and scum that remain are drawn off into mud tanks, where more lime is added and the mass stirred up. Finally it is delivered to the filter presses, where the mud and other impurities are taken out and the clear liquor containing sugar is sent to the evaporators.

Another method for cleaning, called "precipitation in motion," is to carefully lime the juice and then heat it in closed vessels and under sufficient pressure to carry it through a pipe to large insulated settling tanks.

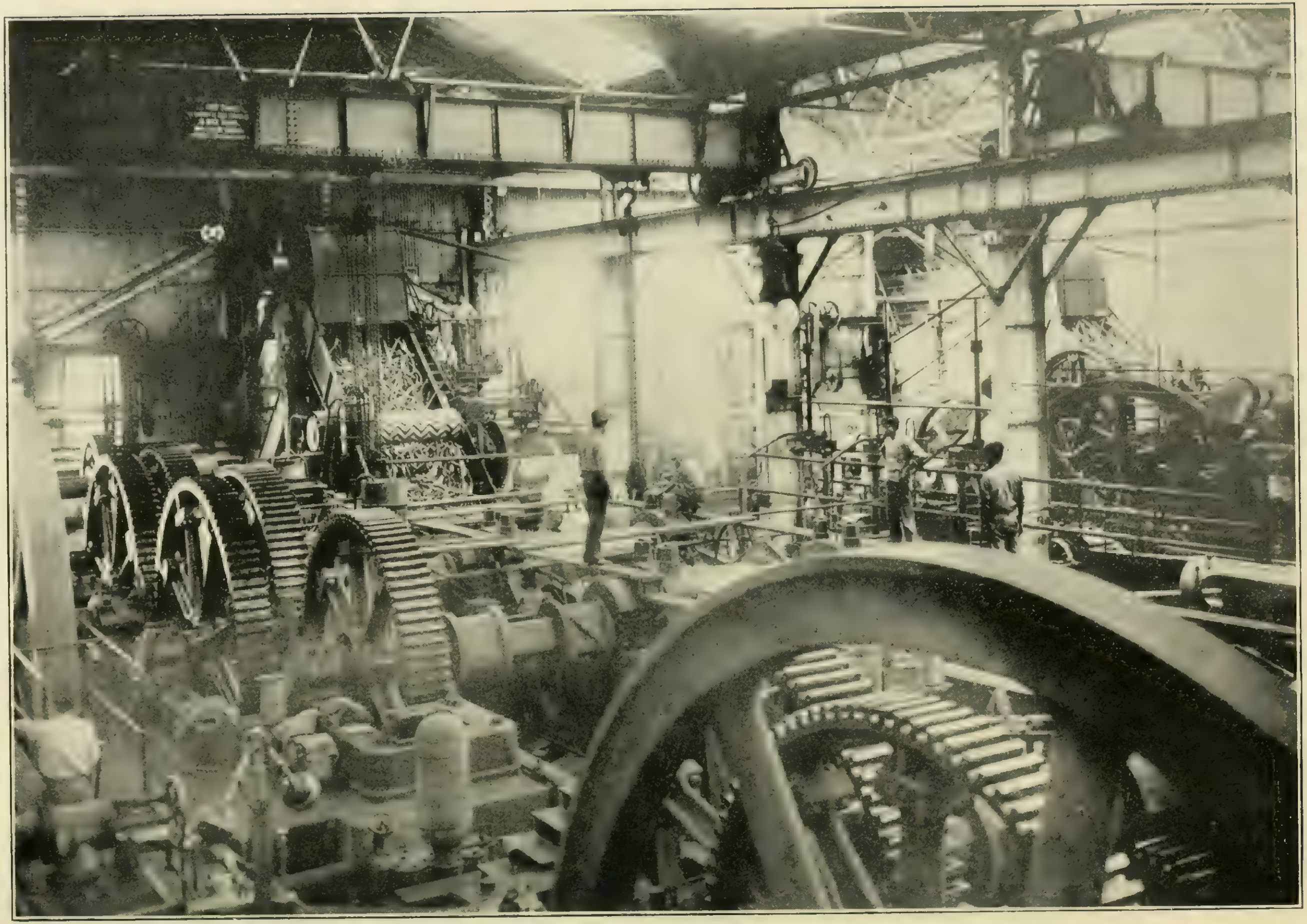
These settling tanks, usually of sheet steel, are made in the form of truncated cones with conical bottoms, the small diameter of the tank being at the top. Suspended in the center is a vertical cylinder somewhat less in diameter than the upper part of the tank. This cylinder extends downward about eight feet to a point opposite the largest diameter, which makes the area between the circumference of the suspended cylinder and the tank at that point very much greater than the area of the cylinder itself. This difference in area is necessary to retard the flow of the juice and allow the sediment, mud and insoluble solids to be deposited at the bottom of the tank.

The juice is delivered by a pipe into the top of the cylinder which projects a few inches above the edge of the surrounding settling tank. It passes slowly down the central passageway, turns at the bottom, where its speed is materially slackened, and goes out through a pipe line connected to the side of the tank just below the upper edge.

There are several other methods in general use, but in all of them the principle of settling, upon which the separation or cleaning depends, is the difference in specific gravity between the juice and the dirt. A high and even temperature should be maintained by preventing radiation, as lowering the temperature would increase the specific gravity and viscosity of the juice without increasing that of the dirt in equal proportion.



TWELVE-ROLLER MILL.



MODERN CRUSHING PLANT—TWO FIFTEEN-ROLLER MILLS AND CRUSHERS. CAPACITY, ONE HUNDRED AND FIVE TONS PER HOUR

There are many different types of filter presses, but those at present in general use are long, oblong machines, set horizontally on the floors, with layers of corrugated iron plates, covered with canvas sheets, between which are hollow frames so arranged that the juice will pass from the hollow frames through the canvas to the corrugations in the plates.

In passing through the presses under pressure the sediment, scum and other impurities are caught on the canvas sheets and the clear juice passes through the canvas, down the corrugations and out through small holes in the plates controlled by valves on the outside of the presses, from whence it runs to the evaporator tanks. The sugar in the mud caught in the hollow frames is washed out of the mud with water and is sent to the evaporator, while the mud itself is finally returned to the field, to be used as a fertilizer.

The clarified juice from the settling tanks, filters or presses, is light brown in color, but is thin and watery, and must now be reduced to syrup point. All the suspended impurities have been removed, but some impurities in solution and the original coloring matter still remain. Some of these foreign substances are subsequently eliminated during the process of crystallization in the vacuum pans described later on.

The object to be attained in a raw-sugar house is the production of a sugar containing ninety-six per cent of sucrose, and there is little or nothing to be gained by carrying the process of manufacture beyond the stage that insures such result.

The final extraction of all the impurities and the conversion of the impure raw into pure white granulated sugar is the work of the refiner, which is dealt with in a subsequent chapter.

From the time the juice leaves the cane until it is crystallized it is kept at a high temperature, as cold juices or syrups are viscous and run slowly. High temperatures kill germs, prevent fermentation and expedite manipulation.

## EVAPORATION

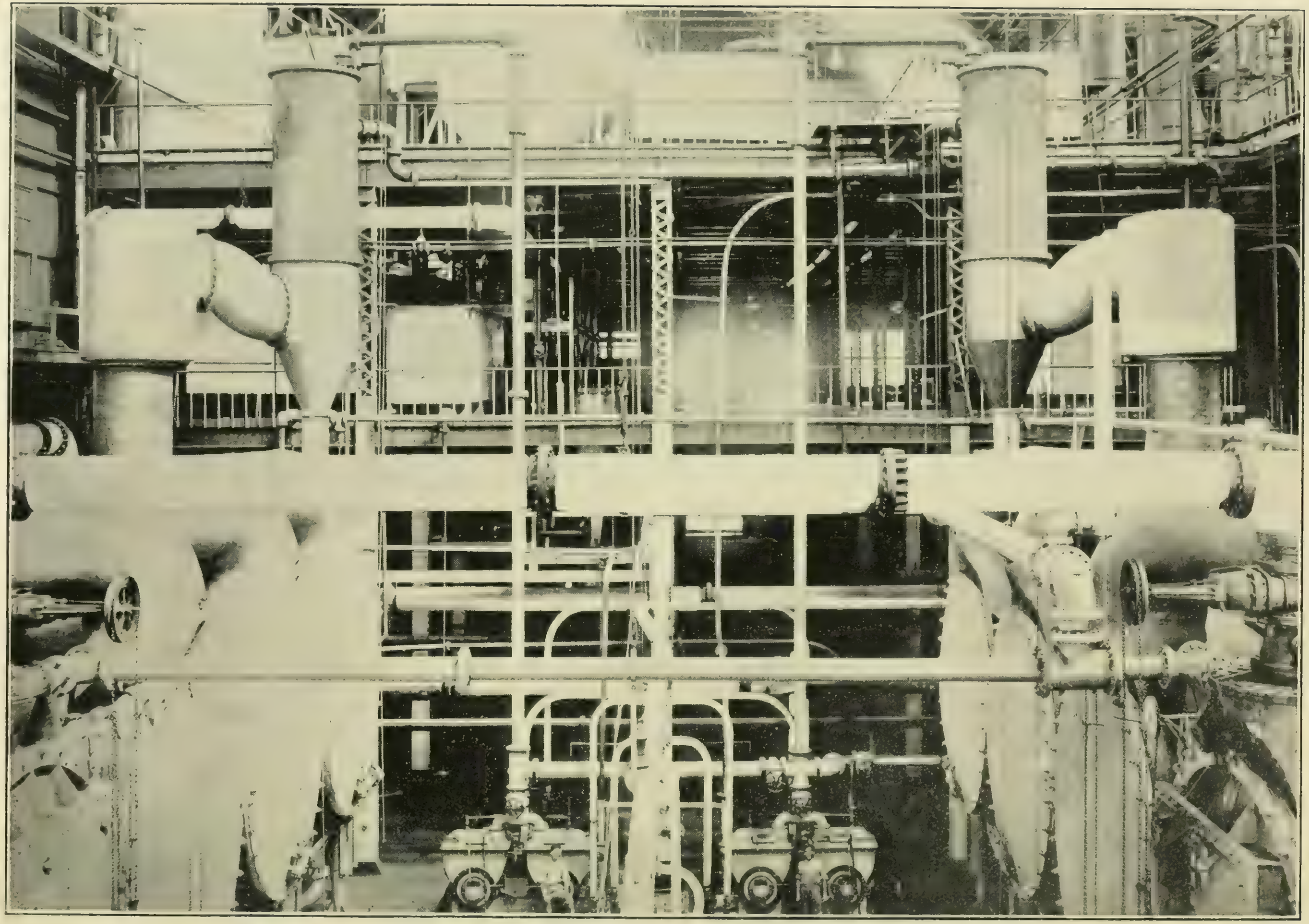
Under ordinary atmospheric pressure at sea-level, water boils at a temperature of 212 degrees Fahrenheit and sugar juice at a few degrees higher, according to its density. This temperature if long applied to sugar juice would tend to burn and destroy the sugar, but the juice can be heated to 250 degrees for a short time without deterioration.

The clarified juice contains about eighty-five per cent of water and fifteen per cent of solid matter. A large proportion of the water must be removed by evaporation. To accomplish this under ordinary atmospheric conditions would require heat increasing from 212 degrees Fahrenheit, as the solution increased in specific gravity above the standard of pure water. This would require a large amount of fuel, and the juice would also be more or less adversely affected by long maintenance of comparatively high temperature.

To obviate these conditions the juice is boiled in a multiple evaporator, the invention of Norberto Rillieux, whose first construction in New Orleans in 1840 was a double effect horizontal submerged tube apparatus which has since undergone many changes and improvements. The theory of evaporation *in vacuo* was extended to two or more cells or vacuum bodies, using the steam or vapor from the first to heat the juice or syrup in the second and so on. At the present time the quadruple effect, or four-cell evaporator, is most commonly in use, although sextuple effects are not rare. The ordinary practice is as follows:

The juice enters cell No. 1 and covers the heating tubes, to which is admitted sufficient steam—generally exhaust from the engines—to cause the liquid to boil. The steam or vapor liberated from this first boiling is conducted through the vapor pipe directly into the heating tubes of cell No. 2, while the juice from cell No. 1 is passed into the second, or cell No. 2, and surrounds

DELIVERING BAGASSE TO FIRE-ROOM



GENERAL INTERIOR VIEW OF MODERN RAW-SUGAR MILL

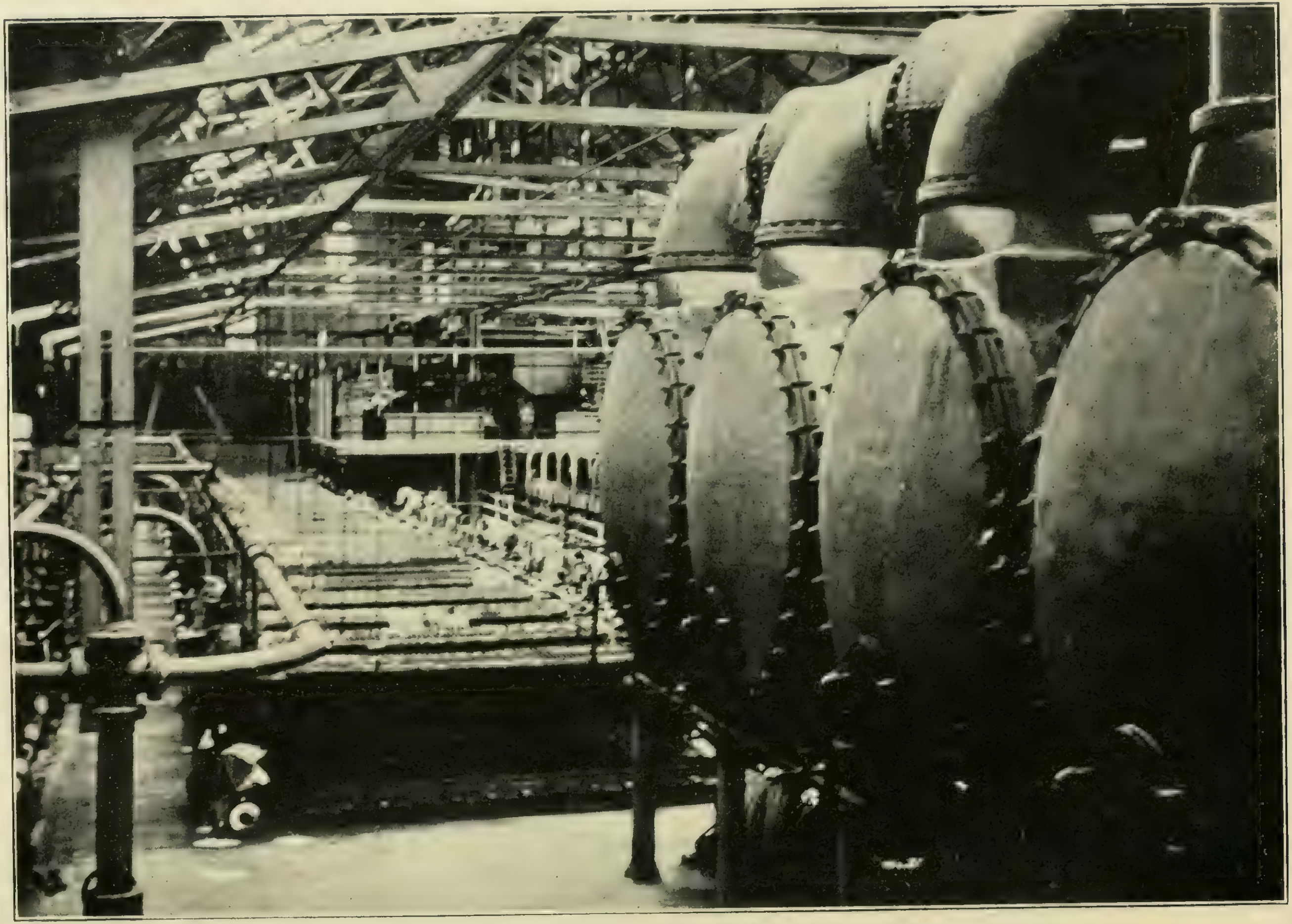
the heating surfaces which contain the hot vapor given off from the same juice in cell No. 1.

As there is little or no pressure above the liquid in the first cell, the juice boils at from 215 degrees to 220 degrees Fahrenheit. By maintaining a vacuum of five inches in the second cell, the temperature at which the liquid will boil is reduced to 203 degrees, and the vapor from cell No. 1 is hot enough to boil the juice in cell No. 2 without any addition of heat. The vapor from cell No. 2 in the same way enters the heating tubes of cell No. 3, while the juice entering this cell is exposed to a vacuum of fifteen inches, which reduces the boiling temperature to 180 degrees, so that the difference of 23 degrees between the conditions of cell No. 2 and cell No. 3 causes a third boiling and evaporation without any additional steam being added.

A vacuum of twenty-six inches in the last cell, No. 4, brings the final boiling temperature down to about 150 degrees. The vapor from this last cell enters a condenser, where it is exposed to a spray of cold water, is condensed and passes down a pipe not less than thirty-four feet long, terminating in a water seal, and called the Torricellian tube, after Torricelli, who discovered that mercury would rise thirty inches in a tube while water would rise thirty-four feet with a perfect vacuum.

The juice in passing through these evaporating cells is boiled to a syrup containing about thirty-five per cent of water and sixty-five per cent of solid matter. It is pumped out of the fourth cell into the receiving tank for the vacuum pan.

This quadruple system of boiling only requires about one-fourth the amount of heat that would be necessary to do the same work in a single vessel. As the evaporators operate continuously, a constant level of the boiling liquid is maintained in each cell, the juice being drawn from one to the other by increasing vacuum and controlled or regulated by means of valves.



SET OF QUADRUPLE EVAPORATORS

tical purposes. The degree of vacuum for any container can be varied easily by mechanical manipulation, so that a vacuum anywhere from one to twenty-eight inches may be maintained.

### CONCENTRATION AND CRYSTALLIZATION

From the receiving tanks the syrup is drawn into the pans by a vacuum ranging between twenty-five and twenty-seven inches. The pans are large cast-iron or copper cylinders, standing in a vertical position, with dome-like tops and conical bottoms, almost spherical in shape. Leading from the top is a large pipe through which the vapors from the boiling are drawn off and condensed. On the conical bottom is a large valve, which may be opened when the boiling is finished to allow the *massecuite* (a French term meaning cooked mass) to drop out.

At regular intervals in the height of the pan there is a series of copper coils, connected with a steam line at one end and a drain line at the other.

The general principle involved in boiling sugar is the separation of the sucrose contained in a solution from the impurities present in that solution, and this is accomplished by evaporation and concentration through the agency of heat. After the sugar is once formed in definite crystals these crystals attract and appropriate the sucrose in solution in the process of building up the crystal structure, while repelling or excluding the impurities, so that, as a consequence, the latter remain in solution. The crystals thus formed are subsequently removed from the solution by means of centrifugal machines. Crystallization, whether in a pure or impure solution, will proceed to only a certain extent, and will only partially remove the sucrose from the solution in one boiling, the limit of crystallization being governed by the amount and nature of impurities present.

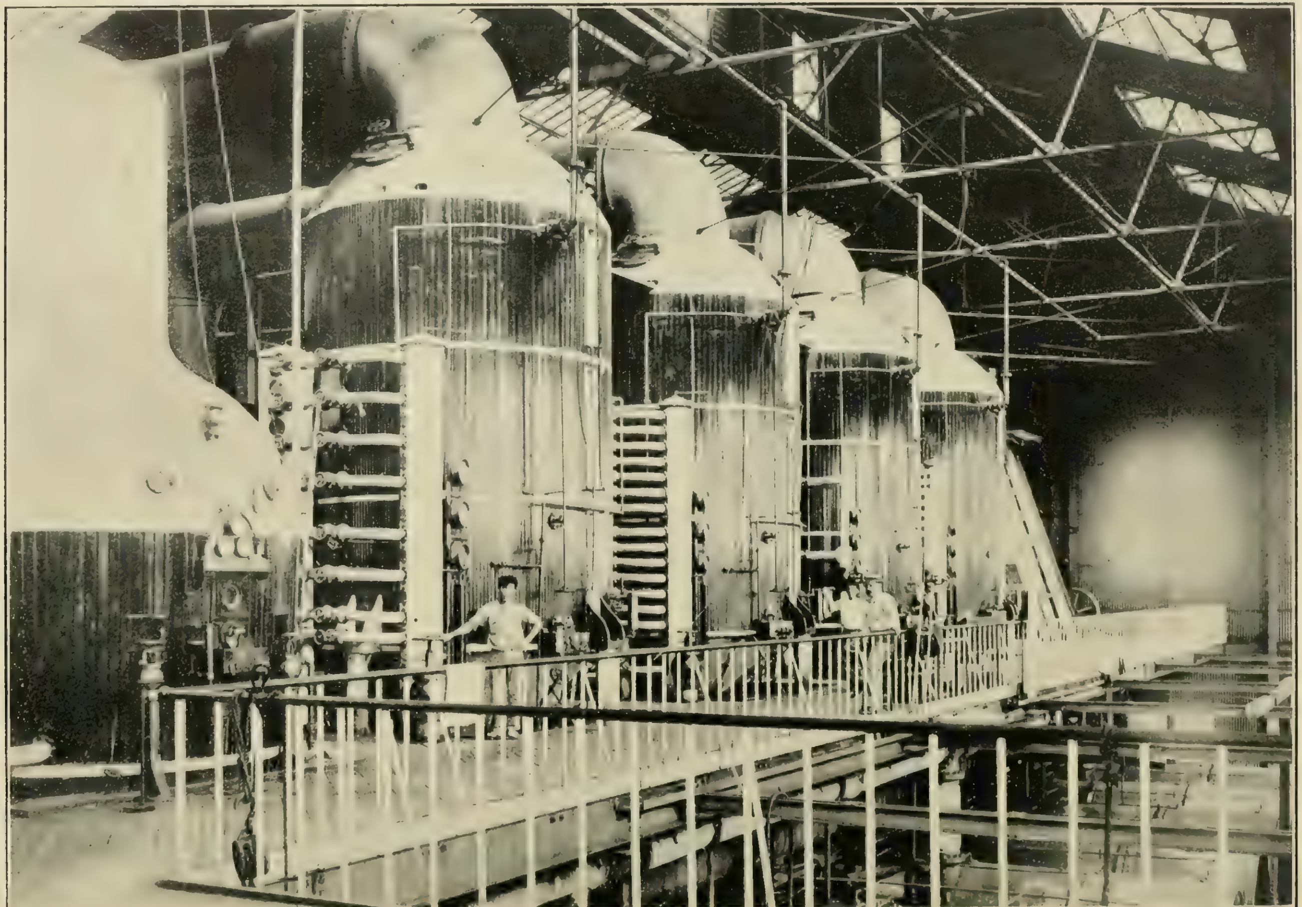
The process of boiling is begun by drawing some of the concentrated juice into the pan and turning steam into the coils,

which starts the boiling. This is continued until the supersaturation is such that minute crystals of sugar form or "grain out." By properly timed admissions of fresh concentrated juice, drawn into the pan by vacuum as before, the crystals grow in size and at last the pan becomes filled with a mass of sugar crystals of regular shape and size, immersed in a thick "mother liquor" containing sugar and the impurities that were not removed by the filters or settling tanks.

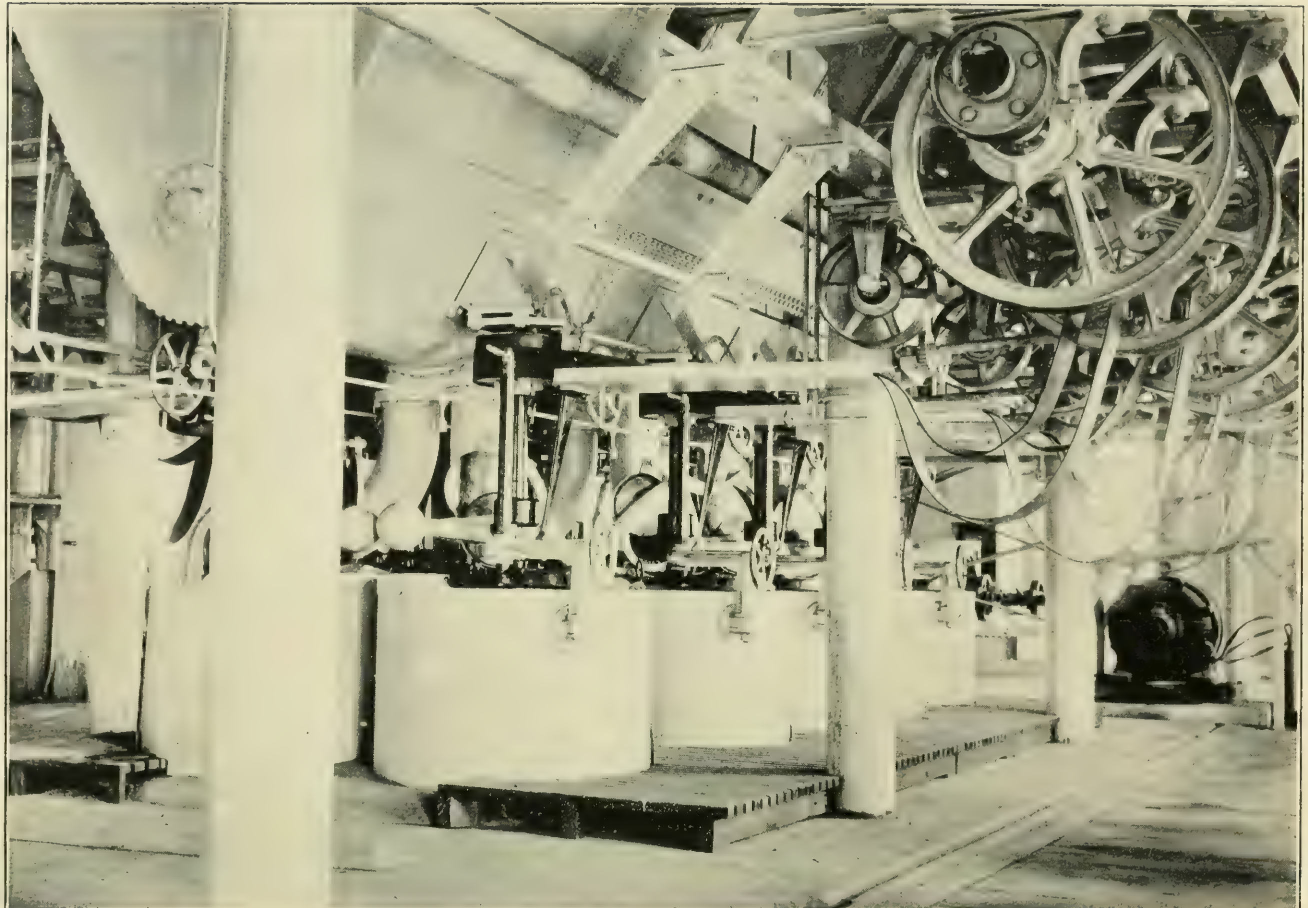
The size of the grain may be varied at will by the operator in charge, who is known as the sugar boiler. After the grains are once formed, their number (if the sugar boiler is an expert) does not increase, but the size does, as the original grain continually builds up on itself from the outside.

The question may be asked, why is all the moisture not boiled out in the pan and the sugar dropped in a dry, crystallized state? There are several reasons why such a course is impracticable; first, because the impurities, which must be eliminated by crystallization and which are carried off in the mother-liquor, would be boiled into the sugar and make it unsalable; second, because to aid crystallization and prevent scorching or burning on the hot steam coils the mass must be kept in active circulation during the boiling process, or, long before all the moisture could be driven off, a large part of the contents of the pan would be burned on the coils; and third, even if it were practicable to boil the contents down to a solid state, the grains would stick to each other and become one solid mass, which would have to be removed from the pan with bars, picks or chisels. Enough moisture, or rather liquor, is left in the mass to enable it to flow from the pan by gravity. This liquor, with the impurities it carries, is subsequently removed from the sugar by a drying or separating process which will be explained later on.

Massecuite is a viscous, sticky, semi-fluid mass of the consistency of half-formed ice.



VACUUM PANS



CENTRIFUGAL MACHINES

The reason sugar "grains" is because the water in the juice has the power to hold in solution only so much sugar. As it goes into the pan, the juice is almost a saturated solution, and as the water is driven off by evaporation, the solids that up to this point have been in solution must of necessity crystallize.

When the sugar boiler decides that the "strike," that is, the massecuite contained in the pan at one boiling, is satisfactorily grained, he breaks the vacuum by opening a valve on the top of the pan, thus allowing the air to enter. He then opens the valve at the bottom of the pan and the mass drops into a long tank with a rounded bottom, called the mixer, in which a shaft, equipped with paddles, is revolving. The paddles are for the purpose of keeping the mass agitated and in an even condition. The agitation prevents the grains from dropping to the bottom of the tank and forming a solid block, called concrete.

### PREPARATION OF CRYSTALS FOR THE MARKET

From the mixer the massecuite runs through spouts into the centrifugal machines. Centrifugal machines are cylindrical-shaped, perforated brass baskets, usually forty inches in diameter and twenty-four inches deep, hung on a central shaft suspended from beams overhead, and surrounded by a solid outside curb or casing.

On the shaft is a pulley, which is driven by a belt connected with an engine or an electric motor. The inside of the basket is lined with a fine-meshed brass screen, which retains the grains of sugar, but allows the liquor to escape freely into the outer casing.

As soon as the centrifugal machine is filled with massecuite from the mixer above, the power is turned on and the machine begins to spin around at an increasing speed until a velocity of one thousand revolutions per minute is reached. The centrifugal action forces practically all the liquor out through the screen

and leaves in the machine all the grains of sugar that were formed in the pan. A little dry steam is sometimes turned in to assist in reducing the moisture in the sugar.

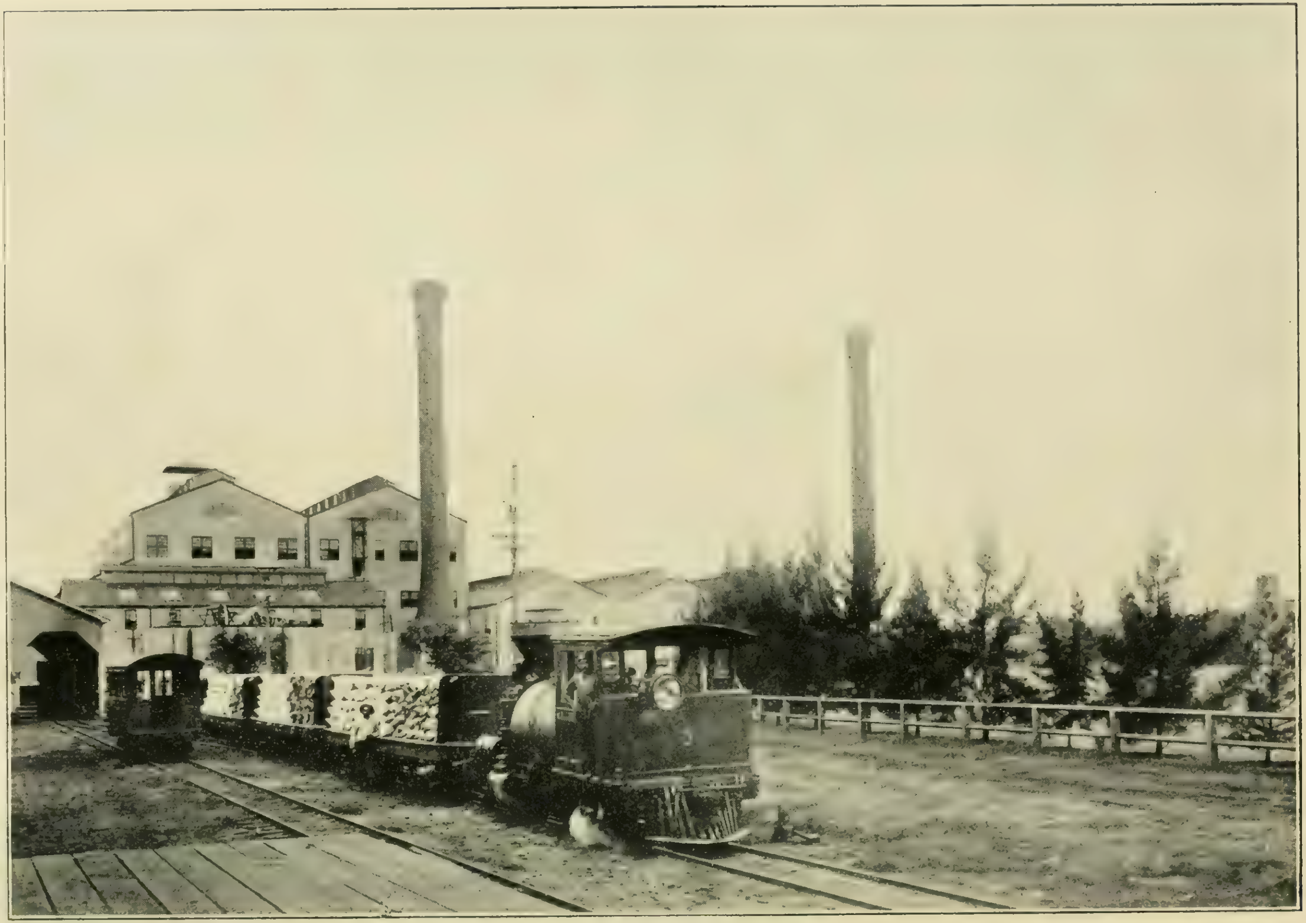
The centrifugal is then stopped, a valve in the bottom is opened, and the nearly dry crystallized raw sugar is dropped into bins. From the bins it is drawn off through spouts and packed in sacks containing about one hundred and twenty-five pounds each.

It has been demonstrated that raw sugar containing a large amount of moisture inverts or deteriorates more rapidly than that with a low-moisture content. It is apparent that as moisture adds to the weight, the transportation charges, which are based on tonnage, are greater in the case of wet sugar than in the case of dry. In many of the modern mills, therefore, a further treatment is given the sugar to reduce loss by inversion and lessen freight charges.

From the bins last mentioned the sugar is dropped into revolving drums six feet in diameter and twenty-six feet long, set at an incline so that as the drum revolves the sugar is carried round to the highest point on the circumference of the drum and dropped to the lower side, at the same time traveling from the receiving to the discharging end. The shape, motion and inclined position of the drum cause a perfect shower of sugar in the drum for its entire length and breadth. While it is revolving a current of hot, dry air is drawn through the drum by means of suction fans, and as a result the moisture in the sugar is absorbed by the air and carried out of the building. At this stage the product has a good hard grain of a yellowish-brown color; contains from ninety-six to ninety-seven per cent of pure sugar and about one-half of one per cent of moisture.

From the end of the revolving drum the sugar is drawn off into sacks holding about one hundred and twenty-five pounds each. These sacks are sewed by machinery and put into railroad

FILLING, WEIGHING AND SEWING SACKS



TRAIN-LOAD OF RAW SUGAR LEAVING MILL

cars to be hauled to the docks at the shipping port, where the cars are switched under huge hoisting cranes or alongside speedy conveyors which carry the sugar into large seagoing steamers especially built for the trade. Some of these ships have a cargo capacity of two hundred and twenty thousand sacks, and they transport the sugar to the buyers on the mainland in San Francisco, New York or Philadelphia, as the planter directs.

The liquor thrown off by the centrifugals is not lost; it is taken back to the pans and reboiled. After this has been done several times and most of the sugar extracted, the purity is so low and the sugar content so small that it does not pay commercially to reboil further, and the residue is sold as molasses. It contains about thirty-five per cent of sugar and from twelve to fourteen per cent of invert sugar, or glucose, as it is generally called.

Some of the waste molasses is mixed with fodder and tender cane tops and fed to cattle and plantation stock, the sugar content proving of great value as a fattening agent and energy builder. Part of the molasses is sprayed on the bagasse as it leaves the crushers and serves, first, as a fuel under the boilers, and, second, as a fertilizing agent in the form of ashes after it has been burned. During the past few years much of it has been shipped in tank steamers to the mainland, where it is used for the manufacture of spirits and vinegar, and also as the principal ingredient in prepared stock foods which are much in demand today.

Every bag of sugar shipped from the plantation is marked to indicate the plantation from which it came. The net weight of the sugar in each bag is recorded, a sample of the sugar taken and its sucrose content ascertained, for it is on the basis of weight and sucrose content that raw sugar is bought and sold.

From the beginning to the end of the process of manufac-

ture, chemists are vigilantly alert sampling, testing, analyzing and supervising the operations. Records are made of all analyses, temperatures, purities, densities, extractions, etc., and the results tabulated for future reference.

The average cost in Hawaii of preparing the fields, planting, irrigating, fertilizing, cultivating and cutting the cane, manufacturing the sugar and delivering it in the New York market, is about $56.00 per ton of two thousand pounds.

# TRANSPORTATION AND DELIVERY OF RAW SUGAR

IT HAS been explained that in Hawaii sugar is packed in one-hundred-and-twenty-five-pound sacks. Methods and customs vary in different countries. For instance, in Cuba it is put up in large gunny bags, each holding an average of three hundred and twenty-five pounds. The same custom prevails in Porto Rico. In Peru, and to a limited extent in Java, sacks containing two hundred and twenty-four pounds are used. A large part of the sugar in Java, however, is put up in bamboo baskets of native make, containing from five hundred to eight hundred pounds. They are about thirty inches in diameter, from thirty-six to forty-eight inches high, and are lined with coarse leaves to prevent the sugar from sifting out between the weavings of the bamboo. Philippine sugar is packed in leaf-lined mats of tough vegetable fiber, each holding about seventy pounds.

These various styles of containers necessitate different methods of handling to and from the ships and by the buyers, but Hawaii will again serve as an example of efficient, modern practice. Outside of what is consumed locally, all Hawaiian sugars are shipped to the mainland of the United States by steamers or sailing vessels to San Francisco, or by steamers to New York or Philadelphia, via the Panama canal.

As sailing vessels are rapidly disappearing from the seas so far as the sugar trade is concerned, reference will be made to steamer traffic only. The steamers are specially built for carrying sugar, having a cargo capacity of from five thousand to thirteen thousand tons, and the best loading and discharging facilities.

When loading in Honolulu, the steamers usually lie alongside wharves covered with immense warehouses, where rapid-speed conveyors carry the sacks of sugar to a point above the ship's hatches and drop them into chutes which guide them down into the hold of the ship, where they are compactly stowed. On the off-shore side of the vessel small steamers from other island ports lie alongside and hoist the sacks by means of steam winches to a point over the hatch and deposit them in similar chutes. When steamers are loaded from both sides in this manner, as much as three thousand tons, or forty-eight thousand sacks, can be loaded in nine hours.

After a vessel is completely loaded and gets her clearance from the custom house, she departs for San Francisco, twenty-one hundred miles away, or for the Atlantic seaboard, via Panama, as the planter may direct.

The voyage ended, and the quarantine and health regulations complied with, she proceeds to the dock of the buyer, usually a sugar refiner. The Hawaiian planter invariably sells his sugar under contract prior to arrival of the vessel at destination.

Planters in other countries operate differently. Occasionally sugar is sold on the plantation at an agreed price, and the buyer arranges his own transportation. The planter sometimes ships his sugar unsold and negotiates its sale while it is en route. If so sold, it is delivered directly to the buyer on arrival; if not, it must be stored in a warehouse at the planter's expense pending sale.

The practice of the Hawaiian planter is to sell his sugar to refineries in San Francisco, New York or Philadelphia, under contracts extending over a term of years. It is agreed that the sugar shall be shipped as soon as made and that the refiner will receive it immediately on arrival, the price for each cargo being that quoted in the open New York market for ninety-six-degree centrifugal sugar on the day preceding its arrival.

STEAMER LOADING SUGAR ALONGSIDE DOCK

LOADING SUGAR AT AN OUTPORT IN HAWAII

The value of raw sugar, like that of other staples, is based on supply and demand, and the price fluctuates from day to day according to the requirements of the refiners or the necessities of the sellers.

There are certain rules or trade conditions governing all sales, so that when one man buys and another sells at an agreed price, each knows what he is bargaining for. For instance, raw sugar is bought on the ninety-six-degree centrifugal basis, that is, the price agreed to be paid is for centrifugal sugar containing ninety-six per cent of sucrose. If it contains more sucrose, a higher price is paid; if it contains less, a lower price is paid; all according to an established scale of additions and deductions. Then again, the time of payment for the sugar is well understood. It is usually ten days after the sugar has been finally discharged from the ship, as this allows a sufficient period in which to determine the exact weight of the sugar and the percentage of sucrose it contains. An instrument called a polariscope is invariably employed to determine the amount of sucrose present and the results obtained from its use are absolutely accurate. A description of the operation will undoubtedly prove interesting.

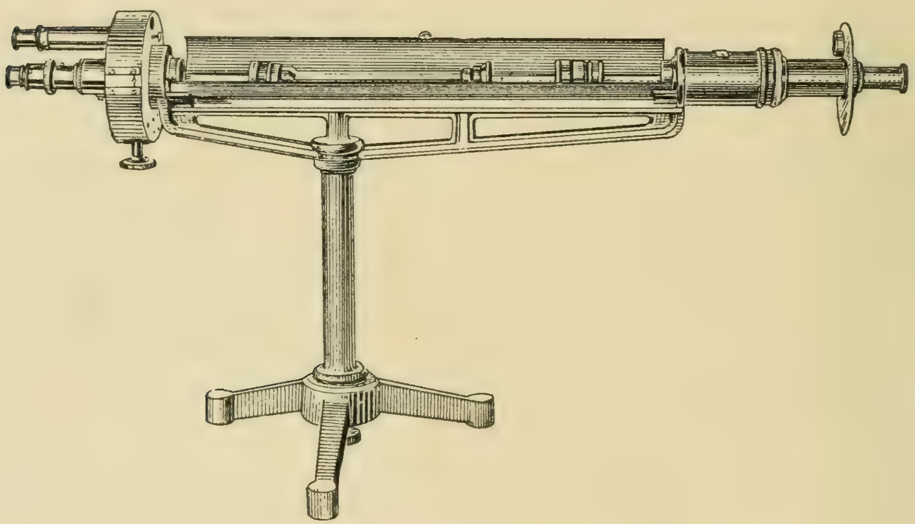
### POLARIZATION

The practical working of the polariscope is based upon the property of sucrose to rotate a ray of polarized light to the right.

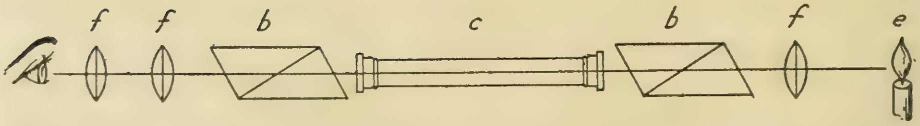
Ordinary light is the effect on the eye of vibrations of the ether. These vibrations occur in all directions, but by certain optical devices they may be confined to a single plane, and light thus confined is called polarized. If rays of polarized light pass through a layer of certain bodies, *e. g.,* quartz, sugar and many others, the plane in which the vibrations occur is rotated, and the polariscope has been devised for the purpose of measuring the rotation of the plane of polarization.

Polarized light, as used in the polariscope, is obtained from the Nicol prism or some development of it. Ordinary light passing through crystals of certain bodies, of which Iceland spar is an example, is split into two rays, one of which is known as the ordinary and the other as the extraordinary ray. A Nicol prism is made of two wedge-shaped pieces of Iceland spar, cemented together with a film of Canada balsam.

The accompanying sketch gives a good idea of the arrangement of an ordinary polariscope.



POLARISCOPE




A strong white light, *e*, enters the instrument through a lens at *f*, to the Nicol prism *b*, by which it is polarized. The ordinary ray is dispersed, while the extraordinary or polarized ray passes

straight through and enters the sugar solution contained in the tube *c*, which has glass ends. In passing through this solution it is given a rotary motion to the right or to the left, according as the sugar in the solution is sucrose or levulose. When it emerges from the tube containing the sugar solution, the now rotated polarized ray encounters a second Nicol prism, of which one of the wedges is fixed and the other movable. This prism is called the analyzer. A pointer, controlled by a thumb screw, is attached to it, and when the correction of the polarized ray's rotation has been made with precision by adjustment of the wedges, the pointer will indicate directly and accurately on a scale the amount of sucrose in the solution under test, because the polarized ray was rotated in exact proportion to the amount of sucrose contained in the solution through which it passed.

The polariscope is made and set so that a standard weight of pure sugar ($C_{12}H_{22}O_{11}$), dissolved in a standard quantity of pure water, and placed in a tube of given length, will rotate the ray of polarized light in passing through, to a point on the scale marked one hundred degrees, the equivalent of per cent. Also, that by using the same quantity of water, but twenty-five per cent, fifty per cent, or seventy-five per cent less weight of sugar, the rotation will show seventy-five degrees, fifty degrees or twenty-five degrees of pure sugar, as the case may be.

A sample is drawn from each bag of sugar and all of these go to make up a general average sample. The standard quantity is carefully weighed, dissolved with the standard amount of water, clarified, filtered and poured into a tube with glass ends, which is then inserted in the polariscope between the eye of the operator and a strong artificial light. When the operator making the test applies his eye to the instrument, he sees a distinct shadow on a lens in the line of vision, one side being light and the other dark. He then turns the thumb screw which adjusts the analyzer until the whole field of vision is neutral, which in-

dicates that the rotation of the polarized ray has been corrected. The pointer on the scale now shows the exact percentage of sucrose present in the raw sugar, ninety-four, ninety-five, ninety-six degrees, or whatever it may be. This test determines the real value of the sugar, based on the market quotation for ninety-six-degree sugar. If the polarization should show exactly ninety-six degrees, the price to be paid for the sugar and the market quotation will be identical.

In most sugar-producing countries the government imposes an import tax on all foreign sugars, in order to obtain revenue to defray governmental expenses and to protect the domestic industry, if any, against competition with other countries in which cost of materials and labor may be lower. Commodities produced in a country naturally add to its development and wealth, and this explains the fostering of the sugar industry by various governments.

The United States duty on foreign sugar is at present $1.256 per one hundred pounds of ninety-six-degree raw sugar. On account of our treaties with Cuba, the Cuban planter is allowed a deduction of twenty per cent, and, therefore, pays a duty of $1.0048 per hundred pounds, which, owing to trade conditions, is the duty effective today in the United States.

Sugars produced in the insular possessions, Porto Rico and the Philippine islands, are admitted free of duty.

In 1898, the Hawaiian islands, through annexation, became a part of the United States, consequently no duty is assessed on sugar or any other Hawaiian product.

Every vessel coming into a port of the United States must be entered at the custom house, where a record is kept of the port whence she came and of what her cargo consists. If from a domestic port, she is permitted to discharge her cargo without delay; if from a foreign one, customs officials are immediately sent on board to watch the cargo as it is discharged and super-

vise the tallying, checking or weighing, according to the class of merchandise. Besides being weighed, sugar is carefully sampled and the percentage of sucrose ascertained by the polariscope, for the customs duty is based upon the purity of the sugar, all raws testing not above seventy-five degrees polarization paying .71 cent per pound and .026 cent per pound for each additional degree. This is equivalent to 1.256 cents per pound for ninety-six-degree sugar.

The people of the United States used 4,257,714 short tons of sugar in the year 1915. It was nearly all produced within the United States or in countries enjoying tariff concessions, as follows:

| | | SHORT TONS | |
|---|---|---|---|
| Hawaiian islands | (Cane) | 570,375, | U. S. territory. |
| Louisiana | (Cane) | 251,740, | U. S. territory. |
| Domestic production | (Beet) | 861,568, | U. S. territory. |
| " " | (Maple) | 17,248, | U. S. territory. |
| Porto Rico | (Cane) | 336,347, | insular possession. |
| Philippine islands | (Cane) | 134,626, | insular possession. |
| Cuba | (Cane) | 2,062,594, | reciprocity treaty. |
| Foreign sugar | (Cane) | 23,216, | full duty-paying. |
| | | 4,257,714 | |

Aside from the small amount of full-duty-paying foreign sugar imported, the only sugar in the above list that paid duty came from Cuba. It is evident, therefore, that under ordinary conditions an increase in the crops of any of the places mentioned would result in a surplus of sugar in the American market. In 1916, with the beet production of Continental Europe locked up by the war, Cuba's increased output has been absorbed by Great Britain, France, Italy and Greece.

Steamers from Hawaiian ports, after arriving and entering at the custom house and passing quarantine and health officers, proceed immediately to refinery docks to discharge cargo.

# REFINING OF RAW SUGAR

CANE-SUGAR refineries are always located in great seaport towns for the reason that, as practically all cane sugar is grown in the tropics, it must be transported by water to the world's markets.

The refining operation is by no means as simple as may at first appear. It is essential that the finished product be almost chemically pure (99.8 per cent), and the greatest care must be exercised to obtain a perfectly white color, as well as a hard, lustrous grain.

The question naturally arises, why do not the planters of Hawaii, Cuba, Java and other raw-sugar-producing countries carry their process a few steps further and make a pure white sugar as the refiners do? This has been attempted many times, but has almost always been found impracticable, notwithstanding the fact that there is no mechanical or chemical reason why.

Among the arguments in favor of a mainland seaport site, the following may be mentioned:

1. The producing centers are generally far distant from consuming markets. Refineries located in the tropics would be under unusual expense for transporting and selling the refined article.

2. A refinery in the tropics would be out of direct and prompt touch with the individual requirements of the buyers.

3. Refined sugar should be moved and sold as soon as possible after its manufacture, so there follows the necessity for adequate dock and rail facilities as means of quick communication with the market.

4. An abundant supply of pure, soft water for refining pur-

poses, and salt or fresh water for condensing, as well as fuel for the generating of steam, must be readily available. Another most important requisite is skilled labor, which is more easily obtained in populous seaport cities than in the small, isolated towns of the tropics.

5. There are many commodities used in the refining of sugar and in packing it for shipment that can be purchased more advantageously, both as regards price and promptness of delivery, in the great commercial ports than in the sugar-growing districts. Among these are bone-char, lime, acids, cotton filter-bags, burlap, cotton cloth, boxes, barrels, cartons, iron, steel and machinery of all kinds.

6. A sugar refinery is operated the entire twelve months of the year, while a raw-sugar mill must of necessity take care of the crop of cane in about eight months. To refine sugar where it is grown would require refining machinery capable of handling the entire output in the eight-month period, and during the remaining four months the plant would remain idle. This would mean a larger investment proportionately than that made in a refinery in a consuming center, running steadily the year round.

7. Refined sugar very rapidly absorbs moisture, and while in transit from the tropic to the temperate zone it is very apt to become lumpy or caked, which would involve reprocessing at great expense at the point of consumption. The unavoidable damage to the packages in loading and discharging results in heavy expense, as all packages must be delivered to the buyer in first-class condition. To avoid hardening, refined sugar should never be piled very high, and it is an unsolved problem whether refined sugar will stand long ocean transportation in cargo lots without caking and damage by breaking of the inside cotton sacks. If shipped in barrels, the freight rate is proportionately higher.

8. Larger capital would also be required, as refined sugar must be carried on hand and must await the consumer's demand, while raw sugar generally has a prompt and ready market and can be quickly converted into cash.

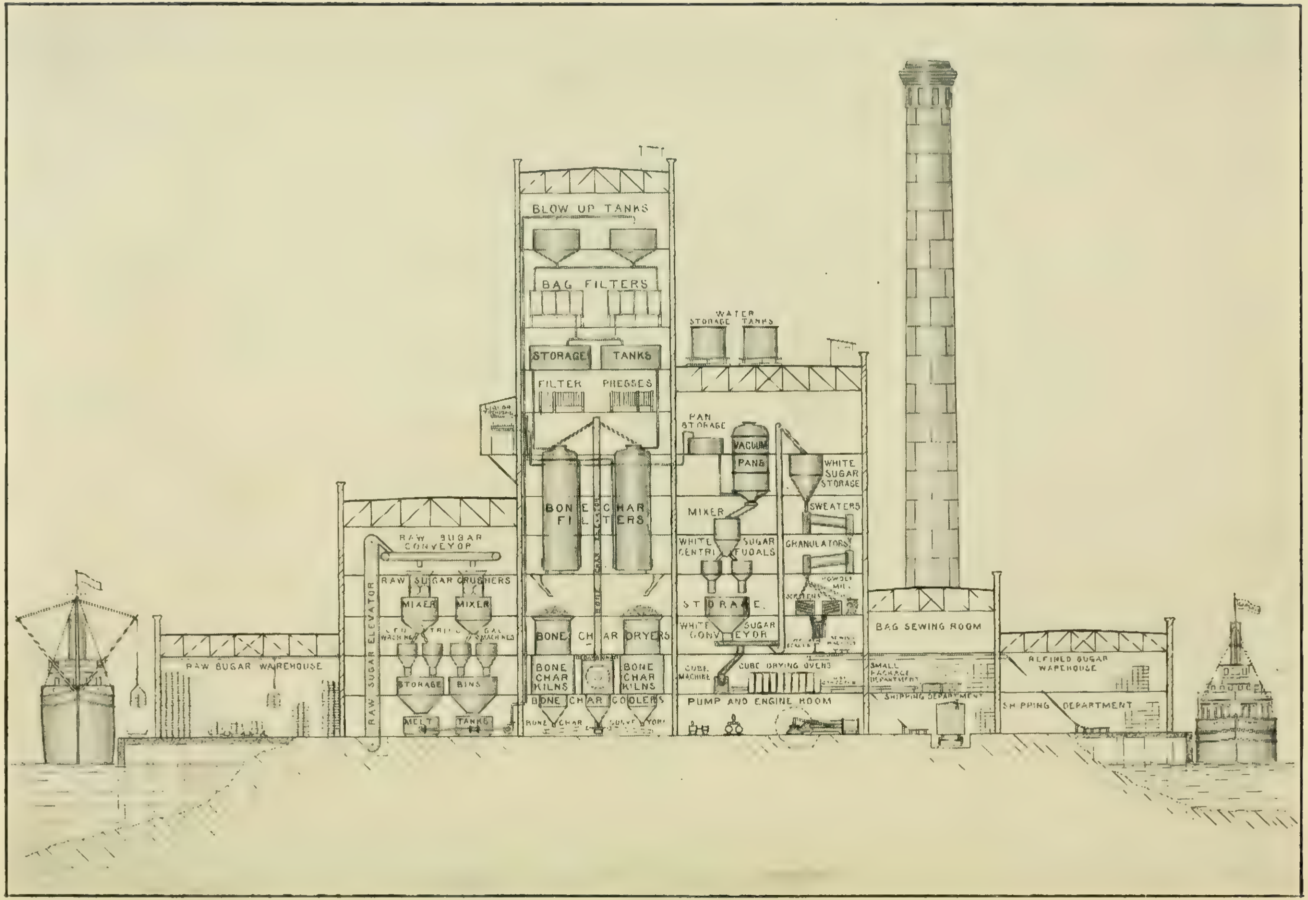
With these difficulties presenting themselves to a prospective sugar refiner in a raw-sugar-producing country, the shipping of raw sugar to refineries at great distances does not seem at all unreasonable.

Raw sugars show considerable variance in their component parts, and so it follows that some are less easily refined than others. Such differences are generally due to diverse methods of culture, amount of fertilizer used, the processes of manufacture and the efficiency of extraction. If the extraction be high, a large percentage of the salts in the cane is taken up, and these salts prevent or retard the complete crystallization of the pure sugar in refining. One part of ash prevents several times its own weight of sugar from crystallizing, hence it is readily seen that raw sugars with a low ash content are preferred by refiners.

Sugar refining is the production of pure white sugar in granular form, after the removal of the impurities from the raw product. Nine operations are necessary to bring about this result:

1. *Washing:*
   Removal of superfluous impurities.
2. *Melting:*
   Changing the solid raw sugar into liquid form by melting with water.
3. *Defecation:*
   Precipitation of suspended and insoluble impurities.
4. *Bag and Bone-char Filtration:*
   Removal of suspended impurities, color and soluble impurities.

A MODERN REFINERY—SHOWING WATER AND RAIL TRANSPORTATION FACILITIES




PLAN ELEVATION OF A MODERN REFINERY

5. *Crystallization:*
   Production of crystals by concentration.
6. *Partial Drying:*
   Purging crystals from syrup in centrifugals.
7. *Final Drying:*
   The driving off of all remaining moisture.
8. *Sorting of Crystals:*
   Sorting of grains according to size to meet market demands.
9. *Packing:*
   Putting in various forms of containers.

A refinery consists of a group of buildings, each of which has been constructed for a special purpose and for convenience and economy in operation. They are as follows:

1. The melt or wash house.
2. The char house.
3. The pan house.
4. The packing house.
5. The boiler house.
6. The pump and power house.

In addition there are offices, shops, laboratories, and last, but by no means least, very extensive warehouses.

To begin at the beginning it will be necessary to start with the steamer laden with raw sugar and made fast to the wharf in front of the warehouse that forms part of the refining plant.

The sugar is hoisted out of the ships in sling-loads by powerful winches, and landed on a platform on the dock alongside the ship. Each sling-load consists of from twelve to twenty sacks, or the equivalent weight in baskets or mats, as the case may be. As soon as the sacks are landed, they are sorted according to mark, put on trucks to be run over a scale set in the floor, and their gross weight recorded.

As the truck leaves the scale, the samplers take a sample from

each sack. This is done with a tryer, a long, hollow steel tube, open on one side and sharp at one end, with a handle on the other for the sampler to grasp when forcing the tryer into the sack. The individual sample from each sack of each different mark is deposited in large closed cans until the cargo is completely discharged, when an average sample of all the individual samples of each mark is made up and used in the laboratory to determine the polarization or sucrose content of the various lots comprising the entire cargo. The value of the sugar is fixed by this polarization.

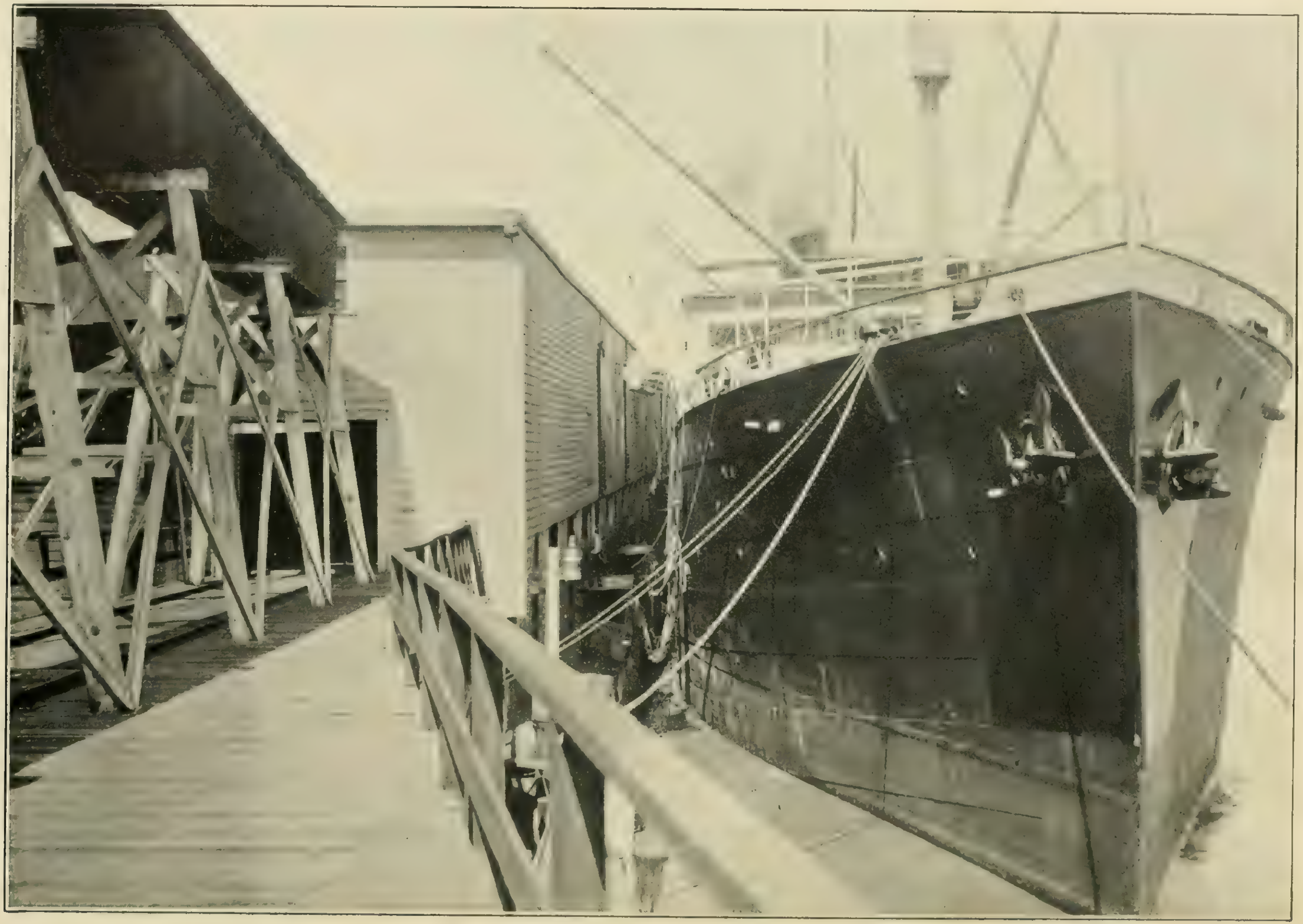
The weights of the various truck-loads of sugar passing over the scales are totaled and the weight of the sacks, baskets or mats deducted, giving the net weight of the sugar.

Hawaiian sacks weigh exactly one pound; Cuban, Javan and Peruvian sacks about three and one-half pounds. Javan baskets weigh from twelve to fifteen pounds, and Philippine mats about four pounds.

In order to facilitate the weighing and simplify the calculations, in cases where the exact weight of the sacks is known, every truck is made to weigh the same by ascertaining the weight of the heaviest and then putting small iron nuts or washers on the rods of the other trucks until each of them exactly counterbalances the heaviest. One truck is then placed on the scale and the scale is brought to a perfect balance, just as though there were no truck on it. In this way the weight of the truck is never recorded, which greatly simplifies the entire weighing operation.

One crew of men will discharge from 1300 to 1500 sacks of sugar per hour from each hatch of a steamer, or a minimum of 731 tons per day of nine hours. As three hatches are usually worked at the same time, it will be seen that from 2200 to 2500 short tons are taken out every day.

From the scales the sugar is deposited on a depressed con-



STEAMER DISCHARGING RAW SUGAR AT REFINERY DOCK

SUGAR STORED IN WAREHOUSE—TWENTY-FIVE THOUSAND TONS SHOWN IN THIS PICTURE

veyor in the floor and carried directly into the melt house of the refinery, except the sugar that must of necessity be stored in the warehouse for future use, in which case it is dumped from the trucks on piling machines that elevate it to any height desired, and it is arranged neatly and compactly by the piling crew.

The wharves and docks of a sugar refinery are, as a rule, scenes of unusual activity and interest. Besides the large number of men engaged in hoisting, trucking, weighing, sampling and piling the sugar, there are the sailors, whose calling always possesses a certain fascination for the landsman. A motley crew they are, bronzed by wind and sun, gathered from all countries and climes. There is the simple, kindly native of Hawaii, gentle-eyed, soft of speech and born with a love for the sea; he prides himself upon his skill in swimming and diving, and when the day's work is done, entertains his shipmates by singing the plaintive melodies of his native land, accompanying himself on the ukulele, the stringed instrument of the South Seas. Should there be a number of his fellow islanders among the crew, the evening's program is almost certain to be varied by the native hula hula dance, which generally brings marked applause from the onlookers. Presiding over the galley, or ship's kitchen, is the almond-eyed Chinaman, now shorn of his queue; an excellent cook who loves to gamble after his pots and pans are washed and put away in place; a shrewd gamester, but scrupulously honest. Beside him stands a fierce-looking Malay, sullen, morose and taciturn, whose sharp, white teeth carry a sinister suggestion of the good old days of cannibalism. His neighbor is a Filipino, short in stature, keen-eyed and alert, while in the background are one or two individuals who from their appearance might be direct descendants of the buccaneers who ravaged the Spanish Main in Sir Henry Morgan's time.

The average sailor is fond of pets, and here there is no lack of

them, parrots and monkeys for the most part, and the sayings of the former clearly indicate a total absence of Sunday-school training.

Sugar ships bring rare fruits and vegetables from the tropics, and the employés of the refinery have plenty of opportunities to enjoy such luxuries as fresh pineapples, bananas, guavas, papaias, alligator pears, breadfruit and mangoes.

A visit to the docks of a sugar refinery during the time vessels from foreign ports are lying there is well worth while, although in these days of steam, the picturesque features are not so pronounced as they were before the passing of the sailing vessel.

### WASHING

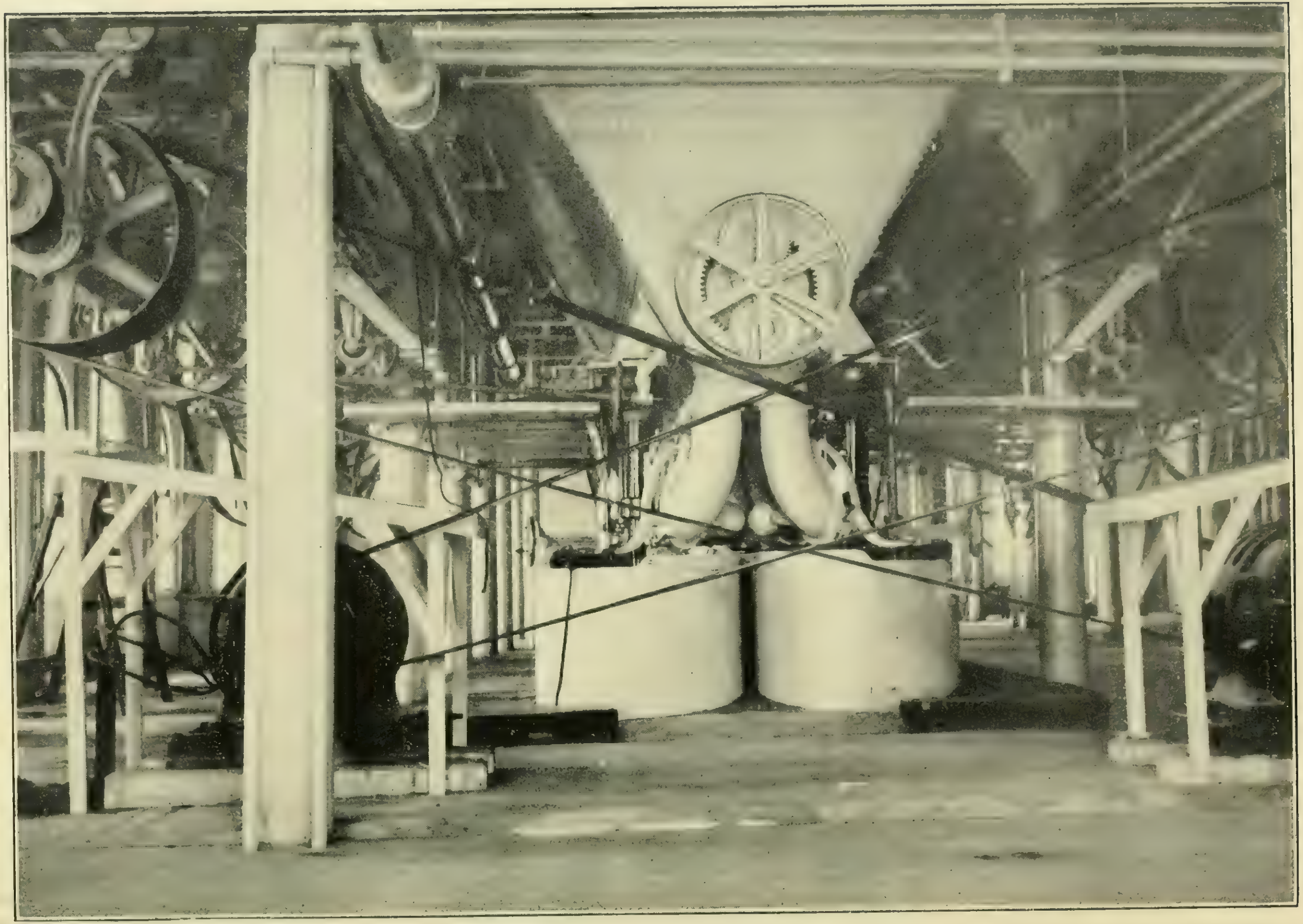
#### REMOVAL OF SUPERFICIAL IMPURITIES

As a starting point in the refining process the melt house will be first considered. It is so called because it is there that the raw sugar enters the refining process by being melted or dissolved in water.

The conveyor, upon which the bags were deposited in the warehouse, delivers them on a platform on the top floor of the building. As they come to this platform from the conveyor, workmen with keen-edged knives seize them and, with a deft, swift slash, cut the twine sewing at the top of the bag without injuring the burlap fabric. The bag is then pulled off the platform, mouth downward, so that the sugar falls out and passes through an iron grating into a large bin beneath. If the sugar should happen to be caked or lumpy, it is sent through crushers and broken up.

As a certain amount of sugar adheres to the inside of the bags, they are washed in large revolving machines and in this operation the sugar dissolves in the water (called sweet water), from which it is extracted later. They are then partially dried in centrifugal machines and hung on hooks on a travel-

CUT-IN STATION—SHOWING SUGAR FIRST ENTERING THE REFINING PROCESS



CENTRIFUGAL MACHINE—MOTOR DRIVEN

ing chain conveyor that passes through the upper part of the boiler house, where the waste heat thoroughly dries them. In returning, the conveyor passes through the bag room and, by means of an automatic device, the bags are dropped alongside the printing presses. Here the name of the refinery, the kind of sugar and the net weight they are to contain are printed upon them. These burlap bags are then lined with a white cotton bag, after which they are made into bundles and sent to the packing room to be filled with sugar. It will be seen, therefore, that the bags from Hawaii in which the raw sugar is received are put to good use. This, however, does not apply to those that come from Cuba or Java; they are too large to serve as containers for the refined product, and after being washed and dried are sold for what they will bring.

The white cotton bags are made at the refinery, and a plant turning out one thousand tons of sugar each twenty-four hours will use twenty-five thousand yards of cotton sheeting per day if all the output is packed in one-hundred-pound bags.

The bin into which the raw sugar is dumped holds enough sugar to keep the refinery supplied during the twenty-four hours run, but the entire quantity is "cut in" during the day. The advantages of this arrangement are that it avoids any delay in operation due to mechanical troubles with conveyors and because more efficient work is accomplished during the daylight hours. The employés prefer to work on the day shift and, wherever possible, night work is avoided.

From the bottom of the bin the sugar falls into a mixing machine, called the mingler. This is an oblong tank with a semicylindrical bottom, near which is a revolving horizontal shaft, with arms or paddles attached which thoroughly stir and mix the sugar with syrup that is added at this point. The reason for using syrup instead of water is that the former, being a saturated sugar solution, does not melt the sugar as water would.

The resultant mixture, called magma, looks a good deal like a soft, brown mortar. It is, in fact, raw-sugar crystals swimming in syrup. This consistency is needed to allow the magma to work freely in the centrifugals, the next operation. Most of the impurities contained in raw sugar are superficial, that is, adhering to the outside of the grain. They may be more or less readily removed by washing the surfaces of the crystals with water.

From the mingler the magma drops to the floor below into centrifugal machines running at the rate of 1100 revolutions per minute. A "charge" consists of about nine hundred pounds of magma. As the machine fills, the centrifugal force causes the magma to rise in a vertical wall around the inside circumference of the basket, at the same time throwing off the syrup that was added on the floor above, and leaving in the machine about five hundred pounds of the raw sugar as it came from the plantation. Water is then sprayed into the machine under high pressure, through a nozzle which divides it into very fine particles and throws it against the wall of sugar in the machine. The water, passing through the sugar by the centrifugal force, washes each face of each crystal and carries off the impurities, together with a certain amount of sugar. The quantity of water used per machine in each filling is from one to two and a half gallons, depending upon the quality of the sugar.

This water, now a syrup, with the impurities and sugar it contains, is drawn from the machine, part of it being pumped to the floor above to mix with new raw sugar coming in. The remainder is treated, filtered, boiled and made into raw sugar, which, in turn, goes direct to the melt or through the washing process again. The result of this washing is that the purity of Hawaiian raw sugar is raised from about 97.2 to 99.2 per cent, and there now remains but 0.8 per cent of impurities to be removed.

The washed sugar is dropped from the centrifugal basket through a large opening in the bottom of the machine with the aid of a mechanical device called a discharger, which greatly reduces the manual labor.

Until very recently the sugar was discharged from the centrifugals by hand, the men digging it out with wooden paddles in a difficult, laborious way. One day, a few years ago, a clear-brained, observant American lad working in a beet-sugar factory, conceived the idea that a centrifugal could be emptied by mechanical means. He worked long and assiduously upon the problem, and after much experimenting and many trials and disappointments was granted a patent by the United States government. Full of hope and confidence, he had several machines constructed and took them to a sugar refiner, sure of being favorably received. He met with rebuff and ridicule. The refinery engineer was too busy with other matters to examine or give any attention to the appliance. The next man to whom he presented it was even more indifferent than the first; he coldly informed the patentee that he had been in the sugar business for thirty years, that no such machine would work, and that the only way to take sugar out of a centrifugal was by hand.

After months of effort and repeated failures, he induced the superintendent of a beet-sugar factory to allow him to install and test the device at his own expense. It was thrown out after a few days' trial, and the inventor became well-nigh desperate, although still positive as to the merits of his discharger.

Finally he succeeded in gaining the ear of the manager of a large refinery, who, after listening attentively to his earnest argument, at length became convinced by it. As a result of the interview, it was arranged between them that the machines rejected by the beet-sugar factory should be installed in the refinery and operated for a period of thirty days, under the direct

supervision of the inventor. The test was successful in every particular and conclusively proved the efficiency of the discharger.

The refiner was gratified because on account of the saving in time the capacity of the centrifugals was materially increased; the men operating the centrifugals were hugely pleased, as the arduous work of emptying by hand was entirely eliminated, and the inventor was happy, for he had vindicated himself.

An order for a large number of the machines was placed at once and every centrifugal in the refinery was equipped with one. Today they are installed in nearly every refinery and factory in the United States, and in many raw-sugar plantation mills as well.

## MELTING

### CHANGING THE SOLID RAW SUGAR INTO LIQUID FORM

From the centrifugals the washed sugar drops to the melter pan on the floor below. This is a cylindrical tank in the center of which is a revolving vertical shaft, to which are attached horizontal paddles that serve to facilitate the dissolving of the sugar with the hot water that is now added. Only enough water is added to bring the resultant liquor to a density of 58.6 per cent of solid matter.

The raw sugar having been washed and, to use a technical term, *melted,* leaves the melt house at this point.

## DEFECATION

### PRECIPITATION OF SUSPENDED AND INSOLUBLE IMPURITIES

From the "melt" the liquor is pumped to the top floor of the char house, which is usually a structure of from twelve to fourteen stories high. The reason for building to such a height is the advantage gained by utilizing the force of gravity and by this means handling the liquors and bone-char from floor to floor without mechanical aid.

The liquor is delivered into a number of cylindrical tanks equipped with a coil of pipe through which steam is passed for heating the liquor, each tank being capable of holding 25,000 pounds of liquor. Around the bottoms of the tanks are perforated pipes through which compressed air is forced to agitate and thoroughly mix the solution. On account of this air being blown in, these tanks are called blow-ups. By means of the steam coil the temperature of the liquor is kept at 190 degrees, which makes it less viscous than cold liquor, thus facilitating subsequent filtration and hastening the reaction of the lime and acid added at this point.

As the liquor comes into the blow-ups it varies in color from a straw yellow to a dark brown, and contains a considerable amount of suspended and insoluble impurities which must be removed. Some of these impurities are present in the raw sugar, and others, such as pieces of twine, lint from the bags, fine particles of leaves from the Java baskets and Philippine mats, are traceable to the opening of the containers in the melt house.

The process of removal is called defecation. In former years this was accomplished by adding bullocks' blood to the raw-sugar liquor in the blow-ups and heating the mixture until the scum which rose to the surface cracked, when the solution below was found perfectly clear, or, in the language of the refinery man, *bright.* Today, however, chemicals are the defecating agents, those most commonly used being phosphoric acid and lime. Phosphoric acid, neutralized with lime, throws down a heavy, flocculent precipitate which, as it settles, sweeps the solution and drags down all the suspended matter, gums, etc., leaving the liquor above clear and transparent.

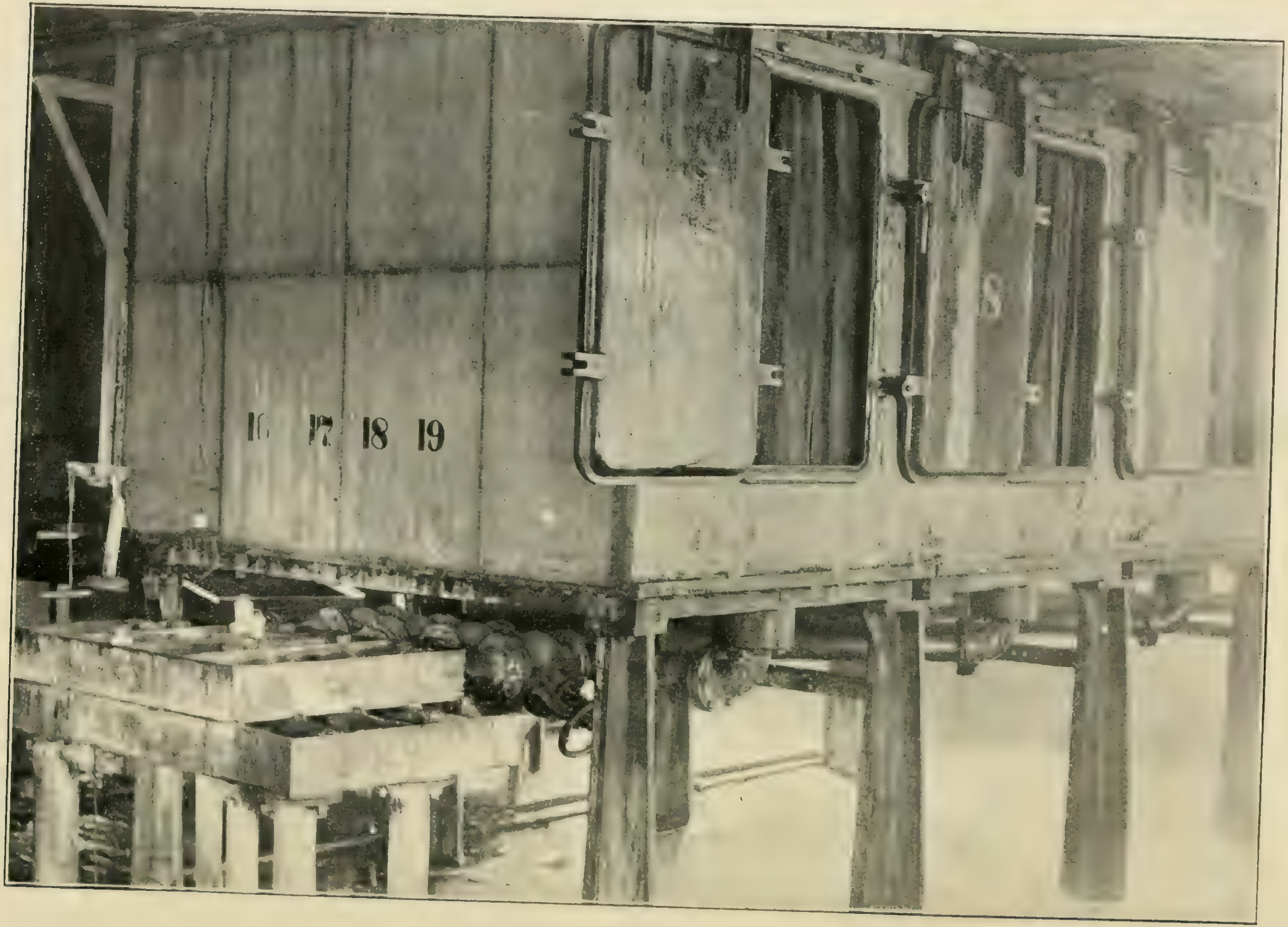
The precipitate must now be removed, and this is accomplished by running the liquor through the bag filters on the floor below. These filters are tight iron boxes, about sixteen feet long, six feet wide and seven feet high. The top of the box is de-

pressed about eight inches below the sides and ends, thus forming a tank. This top is perforated with five hundred holes, one and one-half inches in diameter. From the bottom of the iron box is an outlet pipe leading into tanks below.

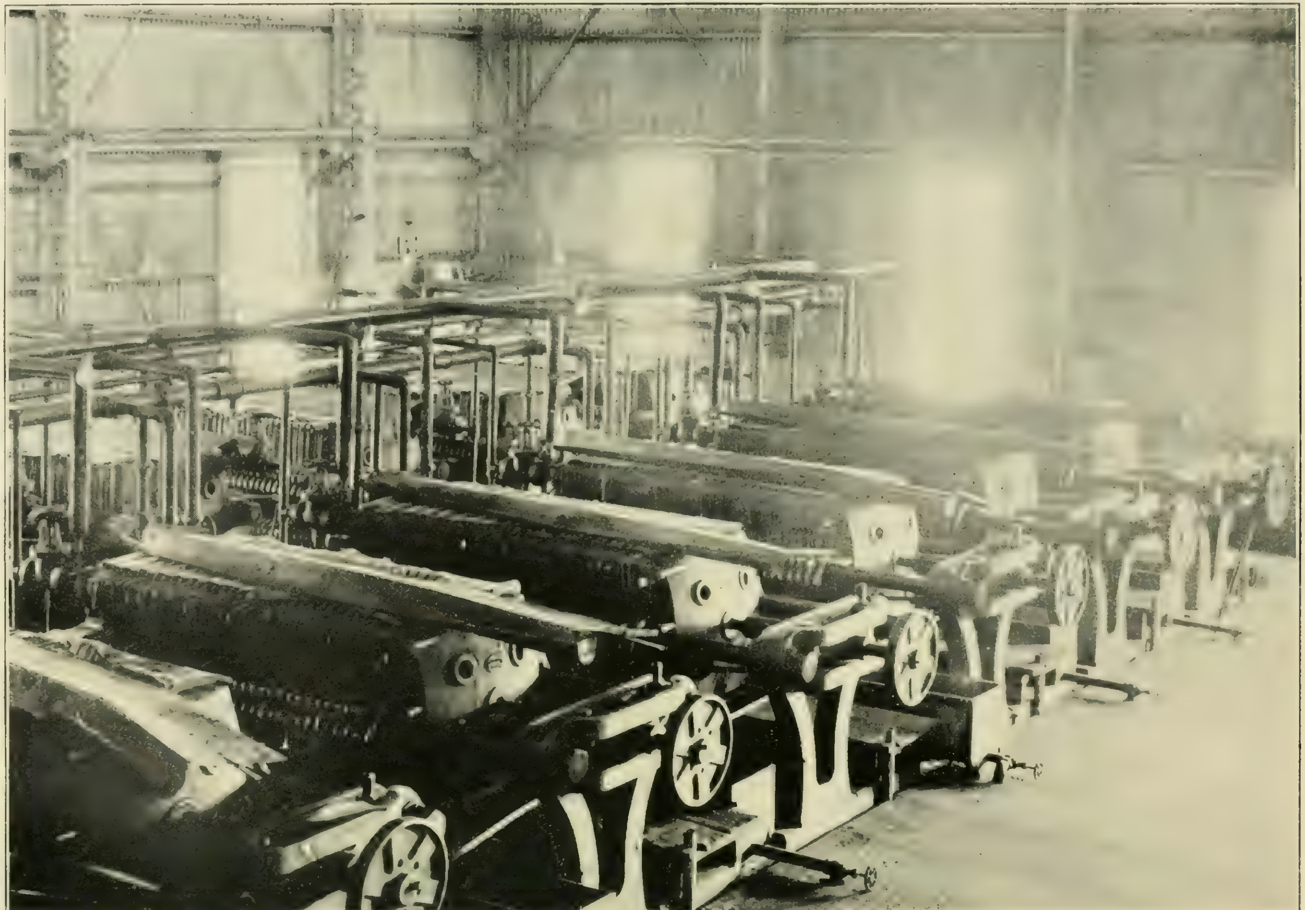
In each of the holes on the inside top of the box is screwed a so-called "brass bottle," conical in shape, to which is securely attached a closely-woven cotton filter bag, about twenty-four inches wide and seventy inches long. This filter bag is encased in a heavier and stronger cotton sheath, or sleeve, about eight inches wide, which adds strength and keeps the twenty-four-inch bag in folds so as to give an effect similar to that of a folded paper filter, frequently seen in drug stores. Each bag filter contains five hundred of these bags, suspended vertically from the top.

Before any liquor is run on the filters, the bags and the iron box are heated by means of steam to bring the apparatus to a temperature of about 190 degrees Fahrenheit. This prevents the chilling of the sugar liquor by cold bags, which would cause the bags to become "blocked," as it is technically called. The liquor from the blow-ups, at 190 degrees temperature, is now turned into the depressed tank on the top of the filter and flows through the perforations into the bags attached on the inside, down through the bags, and finds an exit through the bottom of the filter into the tanks below.

As the first liquor comes through the bags, it is a little cloudy, but in a few minutes, as the pores of the bags fill with the insoluble substances, it becomes perfectly bright, all the suspended and insoluble impurities remaining in the bags, together with the precipitates drawn over from the blow-ups. The cloudy liquor is pumped to the top of the filter and clarified by being run through a second time. It is interesting to know that it is not really the bag that does the filtering, but the thin layer of sediment that is deposited from the liquor itself on the inner




BAG FILTERS—SHOWING BAGS IN PLACE



FILTER PRESSES

surface of the bag. The cotton bags are made in a particular manner, and from a fabric especially adapted to catch the sediment and to form, in conjunction with it, an excellent filtering medium.

The liquor, as it runs into the tanks, must be carefully watched, for sometimes a bag inside the filter breaks, which causes cloudy liquor by allowing the precipitates to gain entrance into the clear liquor. As soon as this is noticed, samples are taken from the outlet of each filter and the defective one found and investigated.

When a bag is torn, or develops a hole, the liquor runs through the opening on the top of the filter so fast that it forms a little whirlpool, which shows the bag that is broken. A wooden plug is immediately driven into the opening and that particular bag cut out. The men on the bag filters soon become so expert that they detect broken bags and plug them before the cloudy liquor gets to the inspection station. It is essential that the liquor be freed from all suspended impurities at this station before the next step is taken, hence great care and watchfulness must be exercised.

In time the coating of sediment, gums and precipitates on the inside of the bag becomes so thick that the liquor runs very slowly and finally stops. The refinery term for this condition is "stuck-up." Depending on the impurities in the original liquor, the bag filters will continue to filter the liquor for from twelve to twenty hours and sometimes longer.

After the bags are "stuck-up," the liquor remaining in them is sucked out by means of vacuum through a small pipe attached to a long rubber hose and inserted in the bags through the holes in the top of the filter. The liquor thus sucked out of the "stuck-up" bags is sent to the blow-ups and reprocessed with new liquor, thus beginning its journey anew.

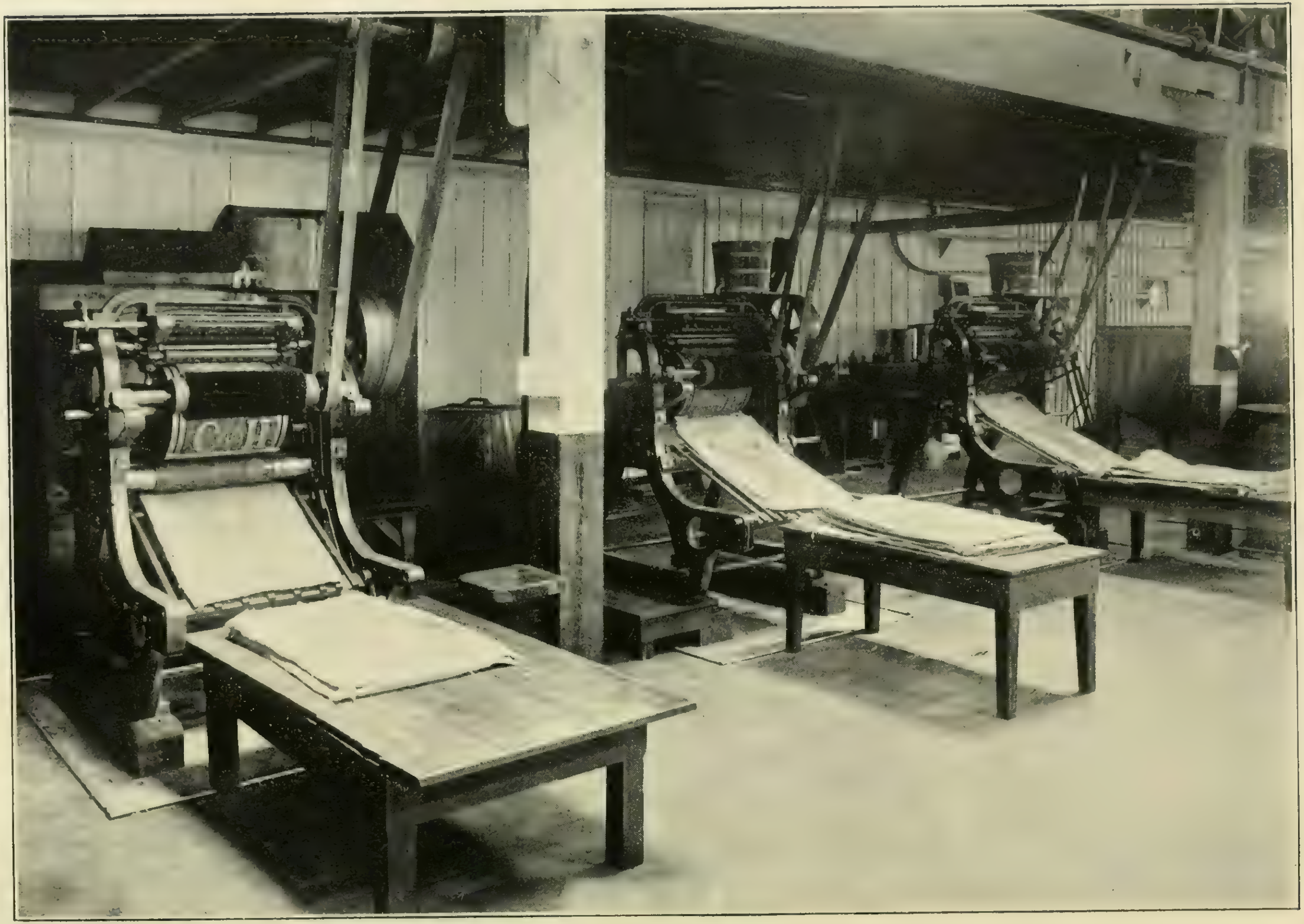
As soon as the liquor is sucked out, hot water is run through

to reduce the sugar contents of the filter. This water is saved and the sugar it takes up is subsequently recovered. The filter is then opened by means of an electric hoist traveling on an overhead track immediately above the filters. Chains are attached to the top of the filter and the hoist elevates top, bags and all, to a point sufficiently high for the bags attached to the top to clear the adjoining filters. The top and bags are then moved along the track to the washing station. Meanwhile another hoist has delivered a duplicate top, with fresh bags attached, to the filter, where it is lowered into place. In this way the filter is again in operation within five minutes. At the washing station the bags just taken from the filter are detached from the top for washing, and the top is sent to a point where clean bags are again attached. It is then ready to go into another filter.

At the washing station the dirty bags are pulled out of the sheaths and turned inside out in tanks containing water, thus releasing a large quantity of the impurities. The bags and sheaths are then thrown into washing machines, where all the remaining impurities and sugar are washed out of them. From the washers the bags are put into centrifugal machines, or through powerful wringers, and dried sufficiently to permit being rehandled. They are then resheathed and made ready to be attached to another top.

The water from the washers contains a large amount of sugar and is conducted to a tank similar to one of the blow-ups, where it is treated with lime and diluted with water at 190 degrees Fahrenheit until it contains only from ten to twelve per cent of solid matter. This liquid is then pumped through filter presses and the impurities removed. The "sweet water," as it is termed, which now contains practically all the sugar, is collected in tanks and the sugar is ultimately extracted by evaporation, filtration and boiling to grain.

MAKING NEW BAGS AND LINING THE WASHED BAGS



PRINTING THE EMPTY RAW-SUGAR BAGS

The impurities removed by the filter presses consist of sand, portions of bags and baskets, phosphates, hair, lime, salts and gums, in fact every kind of foreign matter that finds its way into raw sugar either in the process of manufacture or in transportation. A small amount of sugar accompanies this refuse, but as its recovery would cost more than it is worth, it is allowed to run to waste. The filter-press cake, as it is called, contains valuable fertilizing agents, and when conditions permit it is used for fertilizing purposes, otherwise it is run to waste.

## BONE-CHAR FILTRATION

### REMOVAL OF COLOR

To resume the course of the bag-filtered liquor, from which the superficial, the suspended and insoluble impurities have been removed and which is now the color of clear amber, the next step is bone-char filtration.

Bone-char, bone-coal or bone-black, as it is variously called, is made from the bones of animals. After the fat and glue are removed, the bones are subjected to a dry distillation which carbonizes them. These charred bones are then broken into very small pieces, or until they will pass through a ten-mesh screen and remain on a thirty-mesh screen; in other words, the size of the grains used in a sugar refinery vary from one-tenth to one-thirtieth of an inch. If properly manufactured, the grains are hard, porous, and have a great affinity for moisture.

Bone-char has the peculiar property of removing from the sugar liquor, in some unknown mechanical way, not only the soluble salts but the coloring matter as well. The elimination of the salts and coloring matter facilitates the subsequent crystallization.

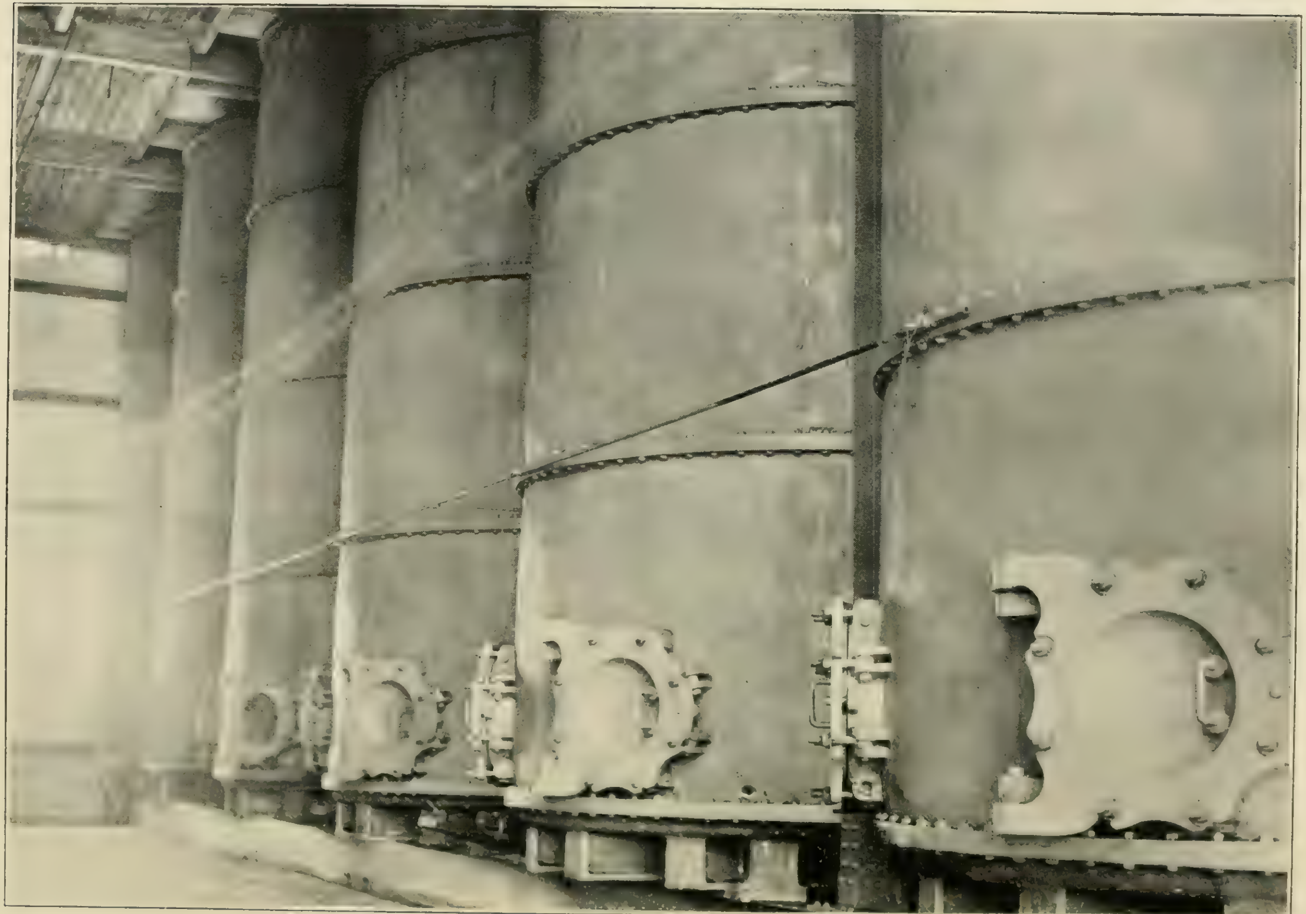
The char house is, therefore, by far the most important station in a refinery, for failure in the char house means failure throughout.

Contrary to the general practice in Europe, beet-sugar factories in the United States do not use bone-char, and consequently do not take all the coloring matter and salts out of the liquor. They secure a white sugar by other methods, which will be explained later on. In a cane-sugar refinery, however, the coloring matter and impurities are entirely eliminated, and the product is invariably pure and white.

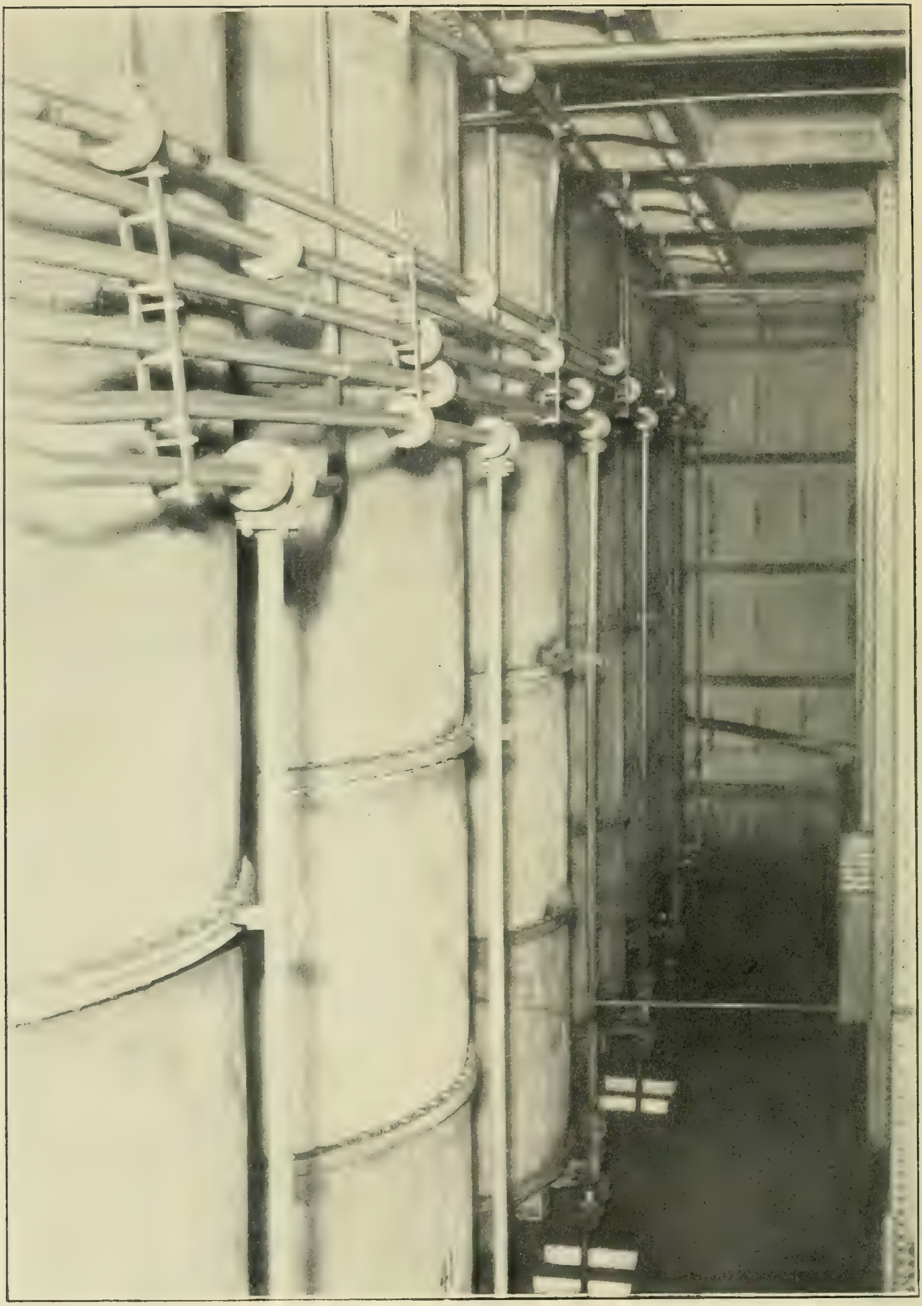
The char filters are cast-iron cylinders, usually ten feet in diameter and twenty feet high, with doors at the top for entrance of the char and openings at the bottom through which it is removed. There are also many pipe connections for the introduction and outlet of liquors, steam, hot water and compressed air. The filters are insulated on the outside with asbestos or some other non-conductor of heat to prevent the temperature of the liquor from being lowered as it passes through. Each filter has a capacity of from sixty thousand to eighty thousand pounds of bone-char.

At the bottom of the filter is a perforated iron plate. Over this is placed a coarsely woven cotton blanket, through which the liquor will pass, but which prevents the char from escaping from the filter with the liquor or wash water. After the blanket is set in place, the char is delivered by gravity through an overhead pipe into the filter, until it is entirely full. The char, as it goes in, has a temperature of from 170 to 180 degrees Fahrenheit, and the bag-filtered liquor which is then run on has a slightly higher temperature.

When the liquor in the filter reaches the top and the char has settled in a compact mass, the cover is put on and fastened securely to prevent leakage. The liquor is again allowed to run into the filter by gravity, from the tanks about fifteen feet overhead. The valve on the bottom of the filter is then opened and the liquor, as it filters slowly through the char, is led through a copper pipe to the liquor gallery, to which station all the char-



CHAR FILTERS



CHAR FILTERS—SHOWING OUTLET PIPES

filtered liquor is delivered. This pipe, instead of leading downward from the filter, leads upward and nearly to the top, so that the flow of liquor through the char will be slow and uniform and the filter will always remain full of liquor. The diameter of the filter is ten feet, while that of the outlet pipe is two inches, so that the flow of liquor through the char is necessarily very slow. The reason for this is that the liquor must remain in contact with char a certain time to enable the char to absorb the coloring matter and soluble salts.

The first liquor from the filter appears cloudy and is sent back for refiltration, but it soon becomes bright, perfectly colorless and transparent as plate glass. This white liquor is pumped from the liquor gallery into the tanks on the top floor in the pan house, ready for the next process, which will be dealt with presently.

After a filter has been running for from twenty-four to thirty-six hours, depending on the character of the sugar in the liquor, the char becomes "tired" or spent. In other words, it has absorbed so much of the impurities and coloring matter from the liquor passing through it that its capacity to absorb more is gone and the liquor begins to show a slight straw or canary color. The inspector in the liquor gallery immediately notices this and orders the liquor stopped. Immediately afterwards a lower-grade liquor is turned into the filter, which forces the first liquor out before it. In due time the man at the liquor gallery notices the number two liquor coming from the filter and turns it into separate tanks. In time a still lower grade of liquor is turned on and the filter run until the bone-char is absolutely exhausted, when it is ordered "sweetened off."

Hot water is then turned in at the top of the filter to wash out the remaining sugar liquor which gradually becomes more and more dilute. When its density has been lowered to about thirty-five per cent of solid matter, it is diverted to other tanks,

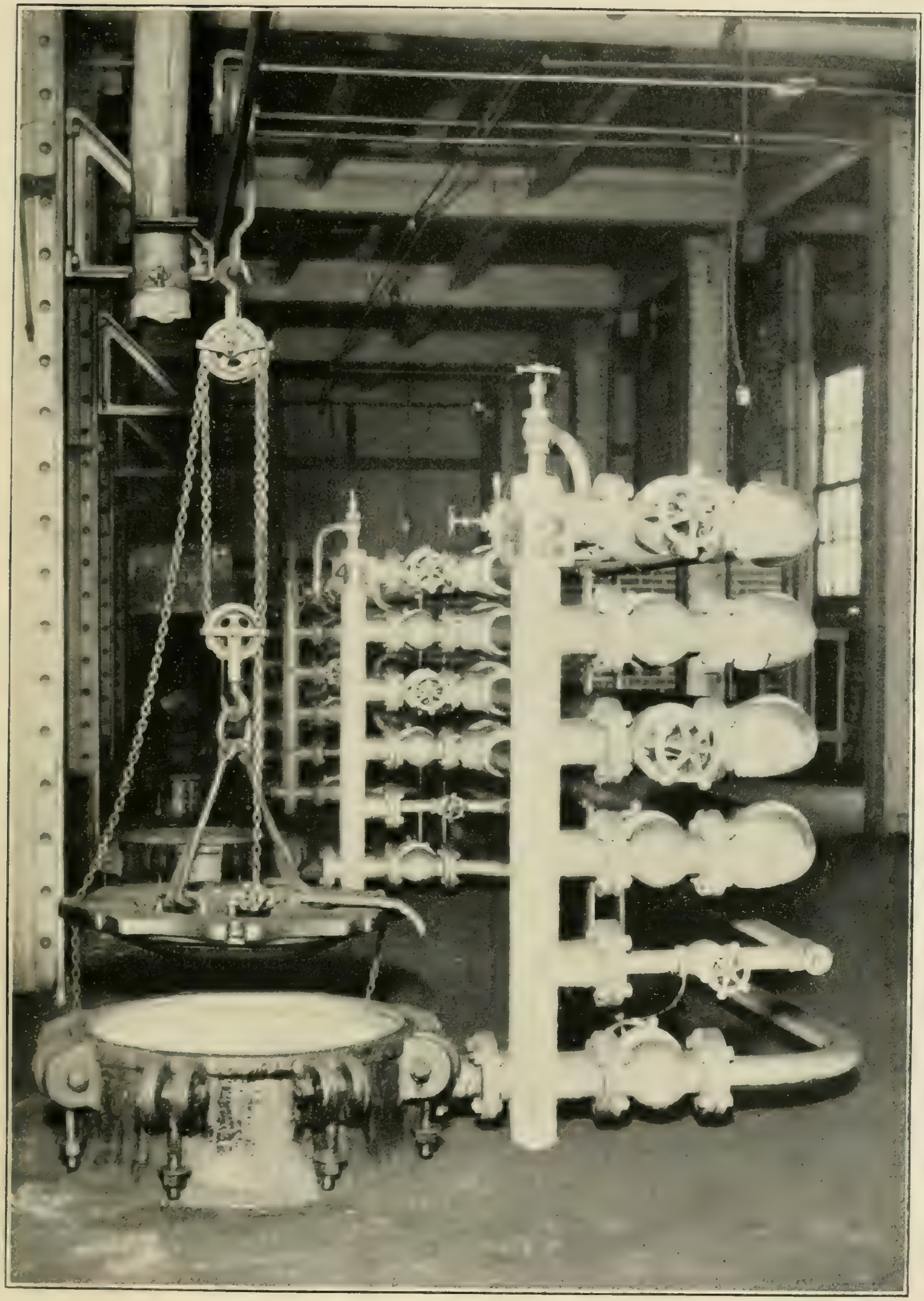
and this is continued until only three-tenths of one per cent of sugar remains in the sweet water, as it is now called. The washing of the char in the filter in this manner, by hot water, is kept up for twelve hours, but as soon as the sugar content falls below three-tenths of one per cent the solution is allowed to run to waste, as the recovery of this small percentage of sugar would cost more than its value.

The sweet water is sent to the evaporators, concentrated to 58.6 per cent of solid matter, and it then begins its refining journey over again.

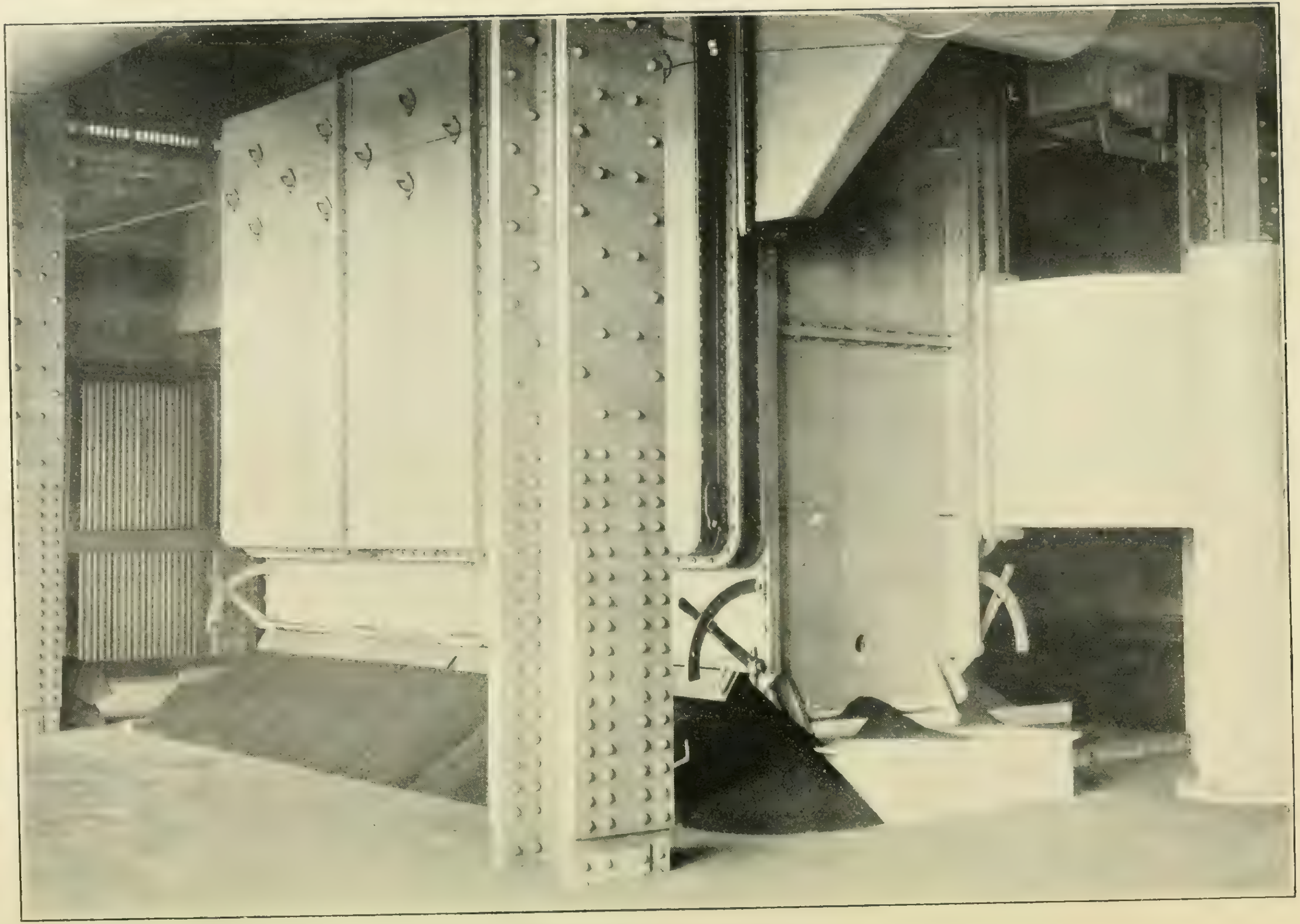
This long and continued washing of the filters is for the purpose of removing as much as possible of the organic and mineral impurities absorbed by the char.

The washing completed, compressed air is applied to the filter to force out the remaining water. The bottom doors of the filter are then opened and the char, containing about twenty per cent of water, drops to the floor below. Here it passes through mechanical driers and is delivered comparatively free from moisture to the kilns. There it is revivified, that is, the organic matter in the char which could not be removed by washing is converted into carbon by being heated to a cherry red in the absence of air. This is accomplished by allowing the char to pass by gravity through the red-hot retorts of the kilns.

As the wet char leaves the filter, it drops on a moving belt which carries it to large cast-iron hoppers leading to the driers immediately beneath, where the greater part of the moisture is expelled from the char prior to its being treated in the revivifying kilns. The driers are made up of a number of thin, hollow, cast-iron, triangular pipes, enclosed in a large, rectangular, outside casing. The wet bone-char passes over these hollow pipes as it falls slowly through the drier. The hot gases from the furnaces of the kilns below pass through these cast-iron pipes, giving off heat as they ascend, thus driving off the moisture in



TOP OF CHAR FILTERS—SHOWING PIPE CONNECTIONS



EXTERIOR VIEW OF CHAR DRIER

the char as it falls down over the outer surface of the pipes. At the same time, hot air obtained from cooling the char in the cooling pipes below the retorts is drawn through the drier, coming in direct contact with the char. The moisture given off by the char is absorbed by this hot air and carried out of the drier and building by fans or smokestacks. By this means the water in the char is reduced to ten per cent, and in this comparatively dry, hot state it runs freely by gravity from the bottom of the drier into a second set of hoppers, through which it drops into the retorts of the kiln. The hot gases, after drying the char, pass out at the top of the drier through a flue leading to a stack outside the building.

The kilns are large square boxes of brick, built around a strong supporting iron structure. On each side of these boxes are a number of large flat pipes of cast iron, nine feet long and twelve inches by three inches in section, the iron being three-quarters of an inch thick. These pipes are called retorts and are arranged vertically in the kilns, forty on each side. The space in the center between the retorts is known as the furnace and extends the entire length of the kiln, a distance of about sixteen feet. Intense fires are maintained in this central space and the flames playing around the retorts keep them red-hot. The upper ends of the retorts lead into the hoppers above and the lower ends to the cooling pipes below. As the char passes gradually through the red-hot retorts, it becomes heated to 900 degrees Fahrenheit and the organic matter it absorbed from the sugar liquor is changed into carbon. In this way the char becomes almost as good as new, or, as the term goes, revivified. Each kiln has a capacity of revivifying sixty thousand pounds of bone-char per day.

If the char in this red-hot state were suddenly exposed to the air, the contact with oxygen would bring about combustion and the char would be quickly reduced to ashes, so a cooling

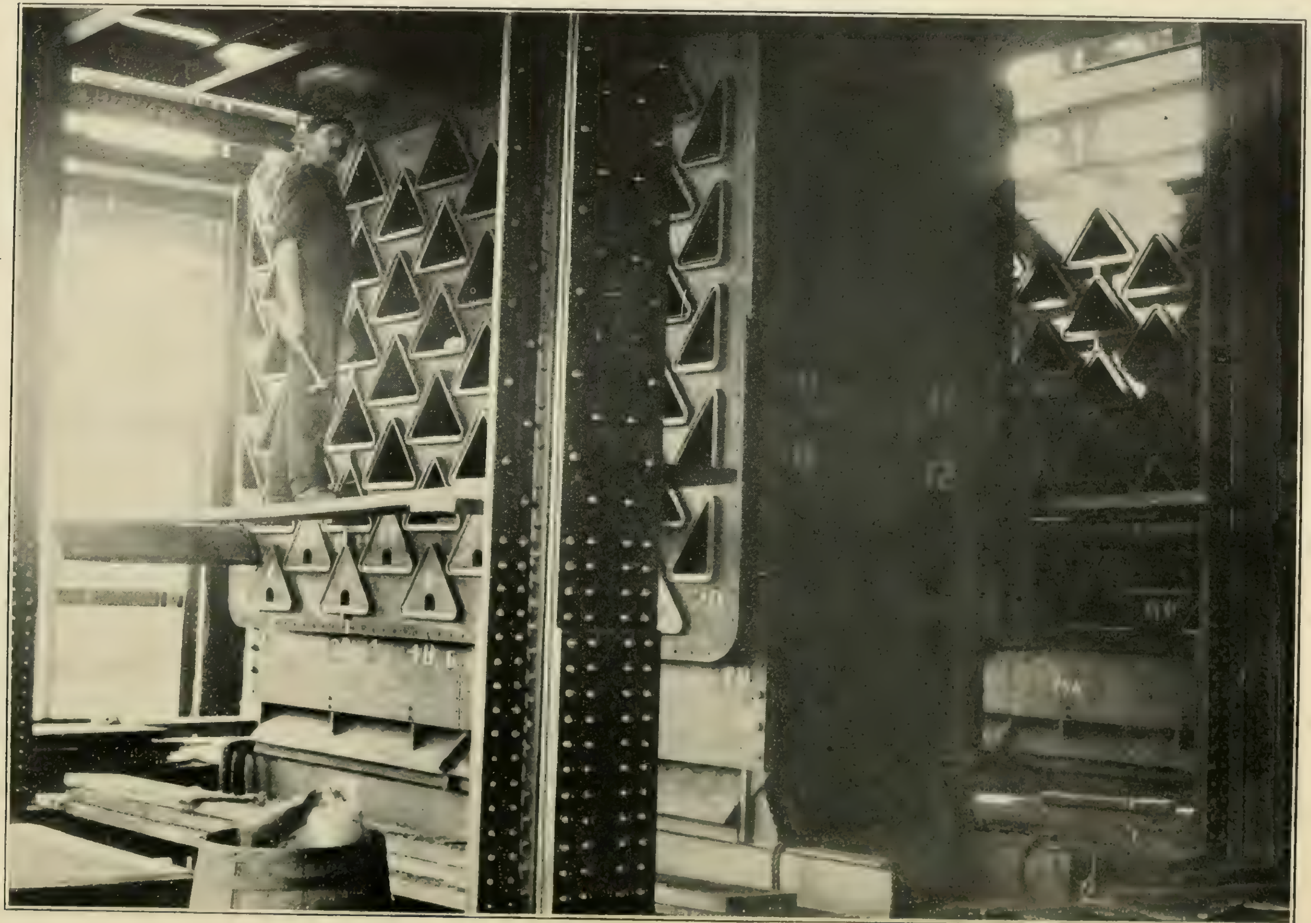
process is necessary. It is, therefore, drawn from the cast-iron retorts into cooling pipes located directly beneath. These pipes are of thin sheet-iron and are about three by four and a half inches in section. There are three under each retort, and a mechanical device at the bottom allows only a small amount of char to escape at a time. This amount can be regulated at will by the operator, and in this way the char is held in the retorts the exact time necessary for its revivification.

A current of cold air circulates continually around the cooling pipes, taking up the heat from the char and delivering it through pipes to the drier overhead, so that when the char leaves the bottom of the pipes its temperature is about 180 degrees Fahrenheit. From the cooling pipes, it drops on a belt conveyor from which it is carried by endless belt or chain bucket elevators to the top of the char filters to be used again.

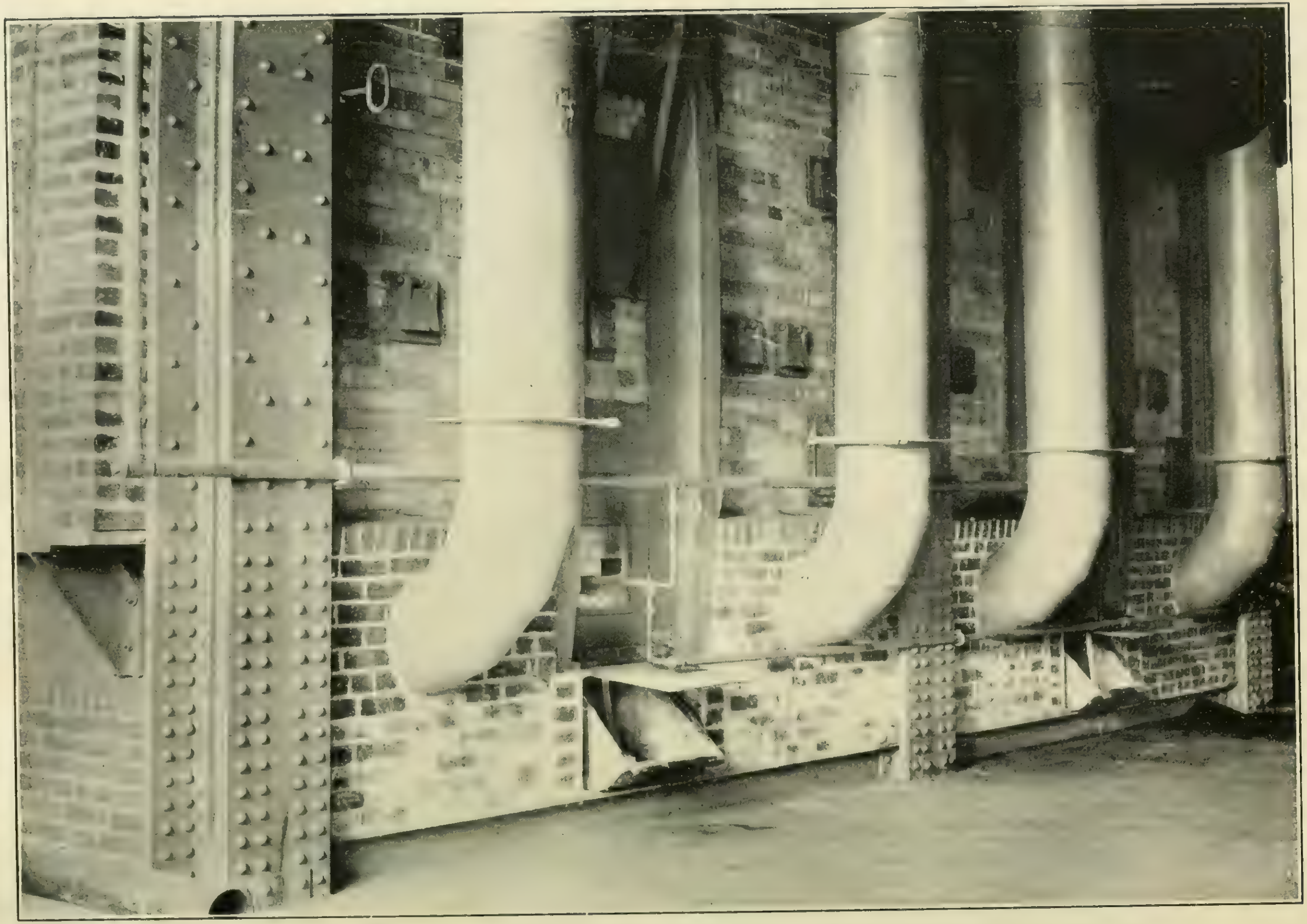
The manipulation of the char filters varies in different refineries, some running the liquor over the char for a longer period than others, but a fair average of the time required for filling, settling running liquors and syrups, sweetening off, washing, applying air and emptying, is eighty-six hours, the shortest time being seventy-two hours. Taking eighty-six hours as a basis, it will be seen that the char is handled and revivified eighty-one times each year after making due allowance for Sundays, holidays and annual clean-up periods.

Each time the char is handled, a certain amount of it is broken into dust, and this is taken out by passing it over fine screens, and also by exhaust fans. Obviously, the amount of dust taken out each day must be replaced by its equivalent in new char. It is estimated that the original char put into the filters will last from five to six years before it finally becomes disintegrated and is taken out as dust.

As approximately one pound of char is required for every pound of sugar melted, it will be seen that as the liquor is



INTERIOR ARRANGEMENT OF CHAR DRIER



EXTERIOR VIEW OF CHAR KILNS —SHOWING OIL-BURNING APPARATUS

in contact with the char for only twenty-four hours out of seventy-two, a refinery turning out two million pounds of sugar per day should have filter capacity for six million pounds of char. The amount of the latter that is handled each year is, therefore, very great and requires a large and costly plant to take care of it properly.

## CRYSTALLIZATION

### PRODUCTION OF CRYSTALS BY CONCENTRATION

The refining process has been described up to and including the purification and decolorizing of the sugar liquor, the last step being the delivery of the pure white liquor into the receiving tanks in the pan house.

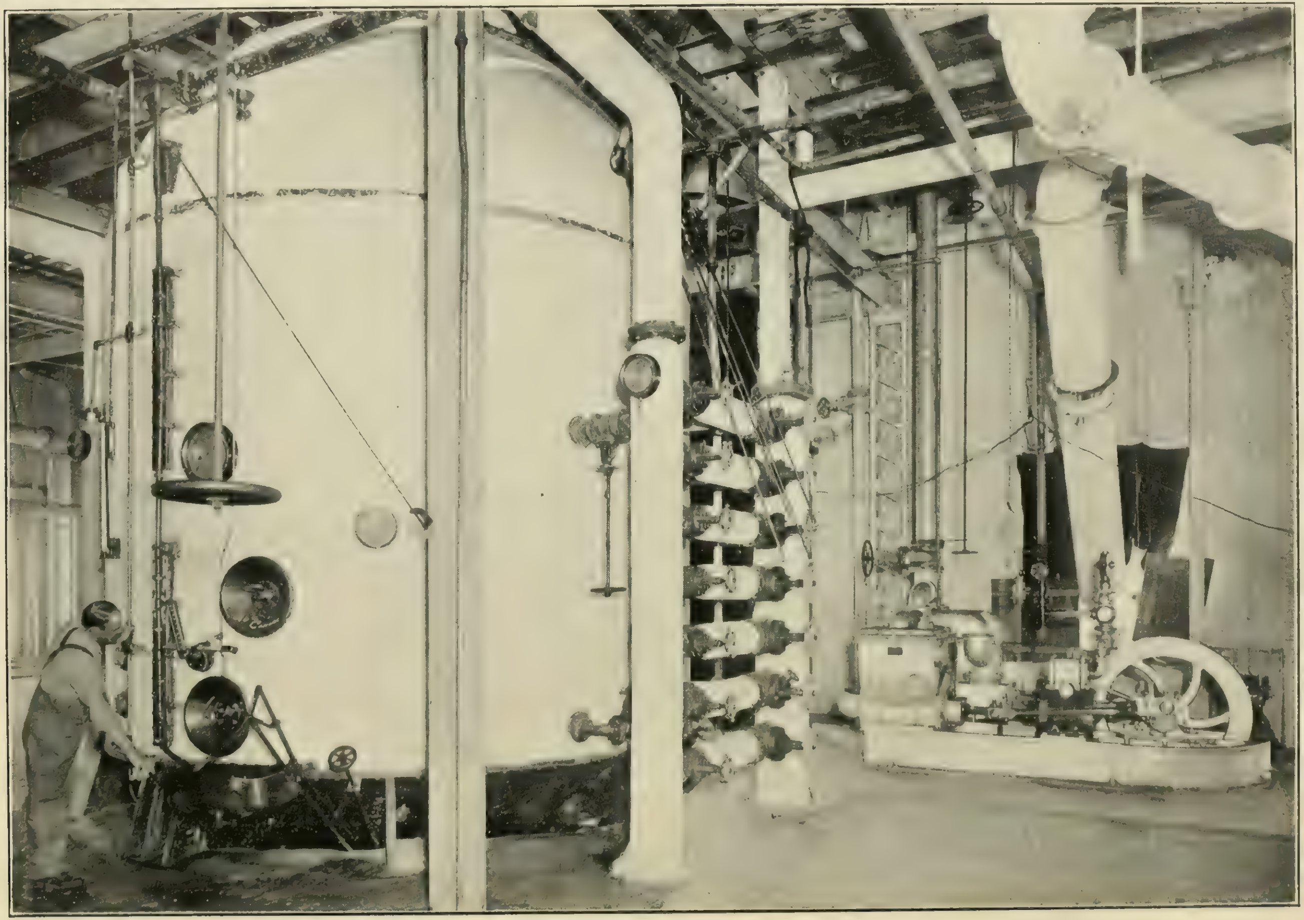
After the white liquor leaves the char filters, the greatest care must be exercised to keep all the machinery, piping and apparatus scrupulously clean, for if any foreign matter becomes mixed with the liquor or sugar it can only be removed by refiltering or remelting.

By means of vacuum, the liquor is drawn from the tanks into the vacuum pans, this being the last operation in which the sugar is handled in a liquid state. From this point on it drops by gravity from floor to floor in a solid or semi-solid form, until it reaches the packing room as a finished product. In a first-class refinery, the vacuum pans, as well as all the piping through which the liquor passes, are made of copper instead of iron and steel, which eliminates the possibility of rust or scale getting into the sugar.

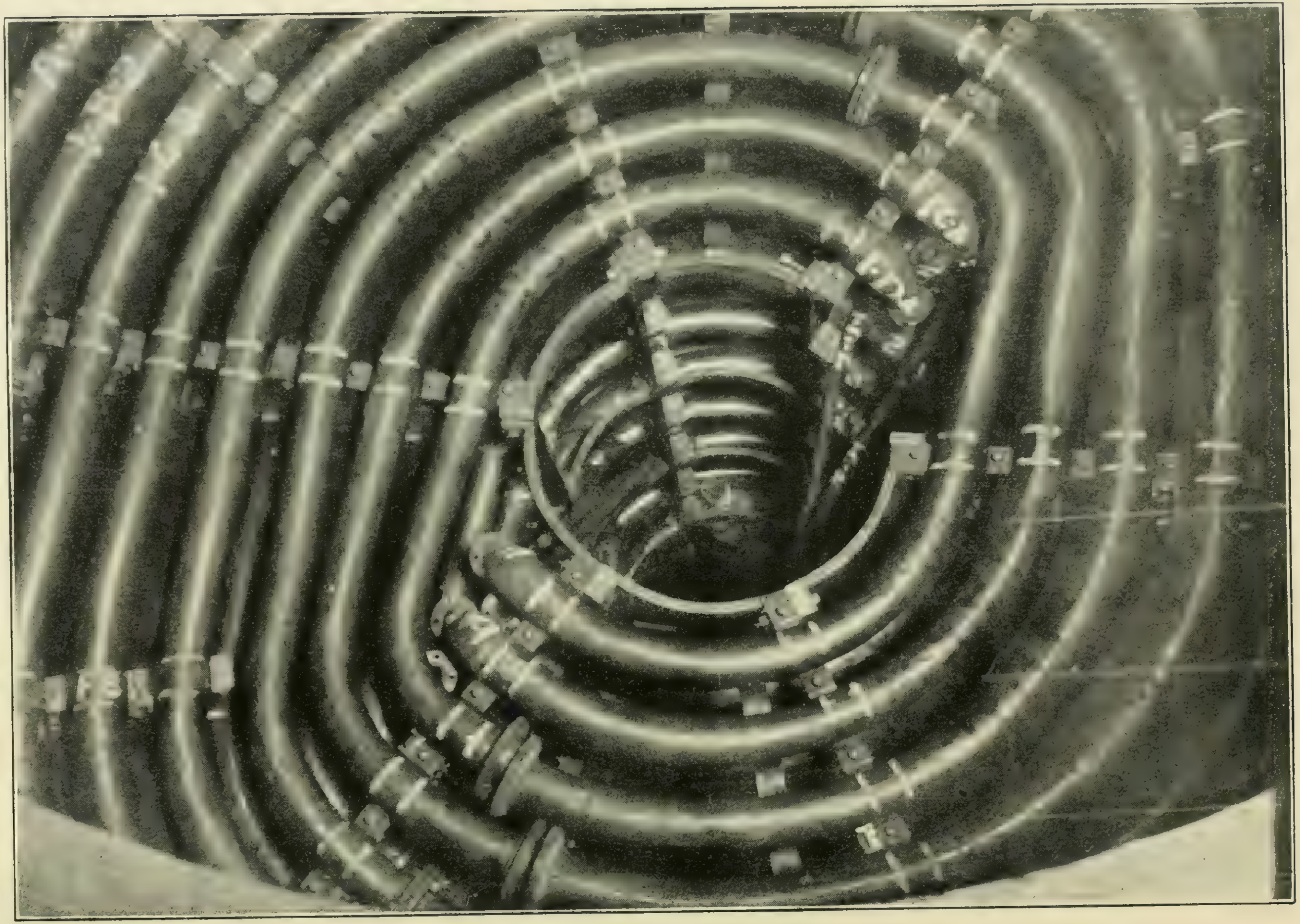
Refinery vacuum pans are usually from fourteen to sixteen feet in diameter and from sixteen to seventeen feet high, while in shape they appear almost spherical. The boiling takes from one hour and twenty-five minutes to one hour and forty-five minutes, and about forty-five tons of granulated sugar can be made at each boiling in a fourteen-foot pan. Before the liquor

is drawn in, the pan is thoroughly cleansed with hot water and steam. All openings are then closed and the vacuum pump started. The air is quickly exhausted, a valve in the pipe line leading from the receiving tank is opened and the pan is given a charge of liquor. Steam is turned into the coils of the pan and the boiling process begins. Soon sufficient moisture is driven off to cause the sugar to "grain." Shortly after the grain forms, another charge of liquor is drawn into the pan and the operation is repeated until the pan is full of a thick, white, mushy substance called massecuite, that looks very much like half-formed ice. The vapor driven off in the boiling passes out through a large pipe at the top of the pan and is condensed by being sprayed with cold water. On account of the high vacuum, the liquor boils violently at temperatures ranging from 140 degrees to 195 degrees Fahrenheit; thus the risk of scorching, discoloration or caramelization of the sugar is minimized.

On the front of the pan is a vertical row of windows made of heavy plate-glass, and through these the liquor is watched during the boiling. The massecuite in the pan is sampled at intervals by the sugar boiler, by means of a "proof stick," a brass rod about three feet long and one and one-quarter inches in diameter, in the pan end of which there is a hollow space. This stick is pushed through an opening in the side of the pan into which it fits tightly, and then partly withdrawn. A small quantity of the contents of the pan remains in the hollow space, and this the sugar boiler removes and places on a piece of clear glass. On holding it up to the light, he sees exactly how the crystallization of the sugar is progressing, and by observing and feeling the crystals, he is enabled to control the boiling perfectly. When he concludes that the evaporation is complete and the massecuite of the proper consistency, the pump is stopped and the vacuum broken by opening a valve near the top of the pan, admitting the outside air. The foot valve is then opened



A REFINERY VACUUM PAN AND PUMP



ARRANGEMENT OF STEAM COILS IN A VACUUM PAN

and the massecuite drops from the pan into a mixer directly underneath. There it is kept constantly in motion by a revolving shaft with paddles, to prevent the crystals from sinking to the bottom. From the mixer it is drawn into the centrifugals and purged of the mother liquor, the pure crystals being left in the machine. The liquor thus drawn off contains whatever impurities may have remained in the original liquor. It is now pumped back and run through the char filters again, after which it is boiled in the vacuum pan and the granulated sugar taken out in the centrifugals. This completes the process of producing crystallized sugar by concentration.

There are many interesting and intricate problems in connection with the extraction of the sugar from the wash waters, sweet waters and low-grade syrups that are constantly accumulating in a sugar refinery, but space will not admit of their being dealt with here. Suffice it to say that the process of extraction is carried to a point where the sugar recovered barely pays for the labor and fuel expended in the operation. The ultimate result is white sugar, table syrup and molasses.

This molasses is used largely in the manufacture of vinegar and alcohol. Mixed with grain and alfalfa meal, it makes an excellent stock food that cattle take to readily and that possesses high value as a fattening agent. The sucrose and glucose content of molasses as it leaves the refinery is about fifty per cent.

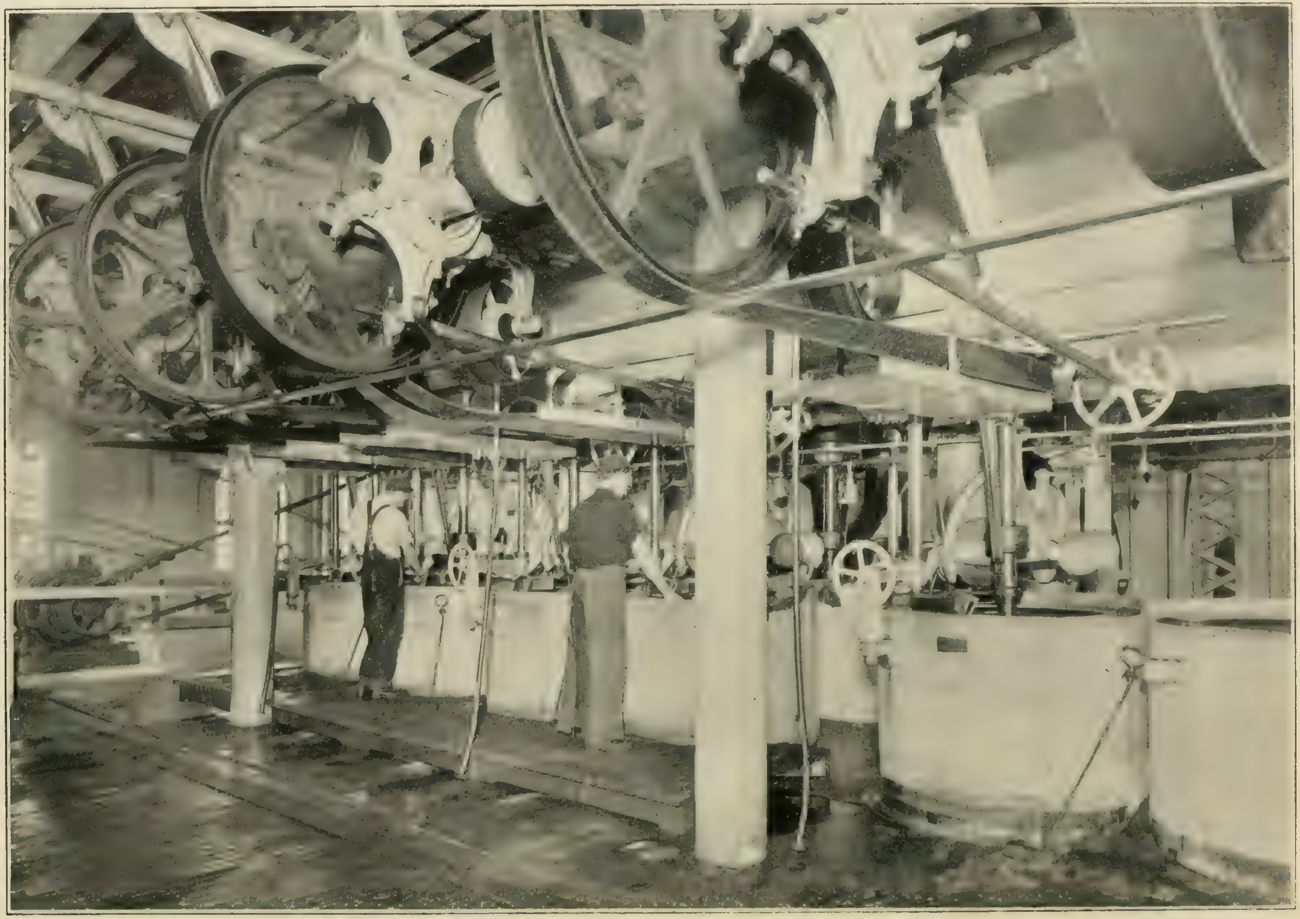
Naturally, in a process involving so much handling, filtering and boiling, there must be some loss, and the efficiency of a refinery is based upon the percentage of granulated sugar recovered from the raw article delivered to the melt. It may be stated for general guidance that, taking an average of the refineries of the United States, one hundred pounds of refined white sugar is made from each one hundred and seven pounds of ninety-six-degree raw sugar melted. Some of the sugar lost

is accounted for in the molasses, in the sediment from the filter presses, and in the wash waters from the char filters. The remainder is the undetermined loss in handling, in sugar destroyed by heating, and in sugar dust escaping during the manufacturing operation. As has been said, the component parts of raw sugars vary more or less, and the recovery in white sugar from two lots of raws, each polarizing ninety-six degrees, might differ considerably according to the refractory matter in the original raw sugar.

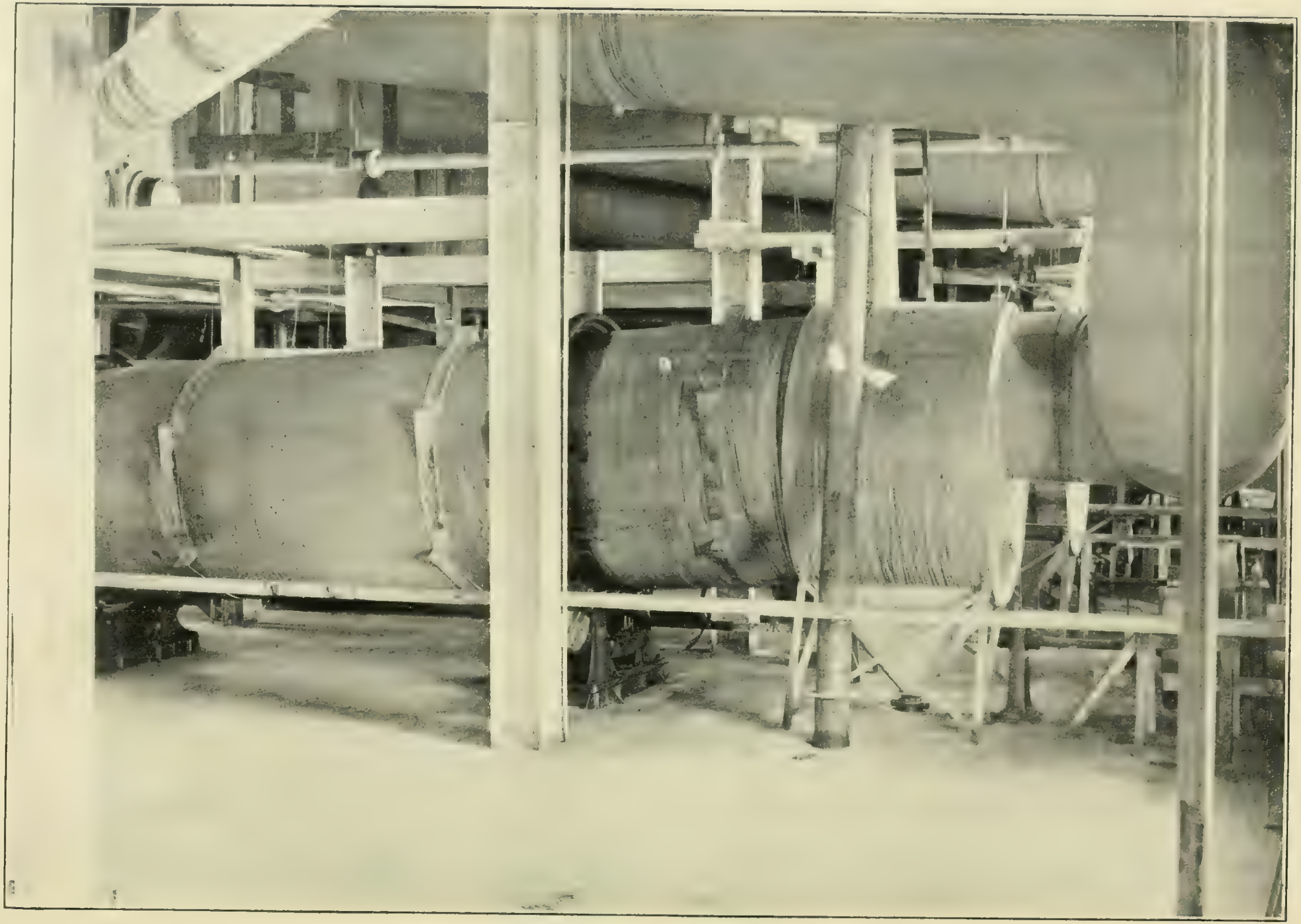
The following figures give a fairly accurate idea of the disposition of one hundred pounds of ninety-six-degree raw sugar in refining:

| | | |
|---|---|---|
| Water, which is eliminated | .70 | per cent |
| Non-sugar, which is eliminated | 3.30 | " " |
| Sucrose loss, undetermined | .75 | " " |
| Sucrose left in molasses | 1.75 | " " |
| Sucrose extracted in granulated form | 93.50 | " " |
| Raw sugar melted | 100.00 | " " |

The undetermined loss includes every loss from the time the raw sugar is weighed into the warehouse until the granulated article is sold to the buyer. It is evident, therefore, that one of the principal items of refining cost is the actual loss of weight in converting raw into refined sugar. Assuming that the raw sugar costs four cents per pound, the refiner has lost on each one hundred pounds melted, four cents × 6½ pounds, or twenty-six cents, less the small value of the resulting molasses. If the raw sugar cost six cents, the loss would be thirty-nine cents. At four cents, the loss is equivalent to $5.20 per ton, or, in the case of a refinery melting two million pounds of raw sugar daily, $5,200.00 for each working day. This does not include any



REFINERY CENTRIFUGAL MACHINES



EXTERIOR VIEW OF SWEATER

of the operating expenses, such as labor, fuel, bone-char, containers, selling expense or administration—just the actual value of the raw sugar lost in the process of refining.

### PARTIAL DRYING

#### PURGING CRYSTALS FROM THE SYRUP

Returning to the sugar left in the centrifugals, the force developed in a machine forty inches in diameter, spinning at the rate of eleven hundred revolutions per minute, is so great that it quickly dispels all the liquor surrounding the crystals, leaving them nearly dry, in a solid, vertical wall. Water, filtered to insure its purity and cleanliness, is then sprayed on this spinning wall of sugar, only to be immediately thrown off through the sugar by the centrifugal motion. In passing through the sugar it washes the last of the syrup from the grains and leaves them perfectly white. Cold water, rather than hot, is used for this purpose, as it dissolves less sugar.

In former years a small quantity of bluing was added to the spraying water in order to enhance the whiteness of the sugar, just as bluing is employed in washing fine linen fabrics. Since the pure-food laws became effective, however, the practice has been discontinued in all cane-sugar refineries.

After the sugar is thoroughly washed, the centrifugal machine is stopped, a large valve in the bottom opened and the mechanical discharger rapidly ejects the sugar (now containing only about 1.2 per cent moisture) from the machine into a storage bin beneath.

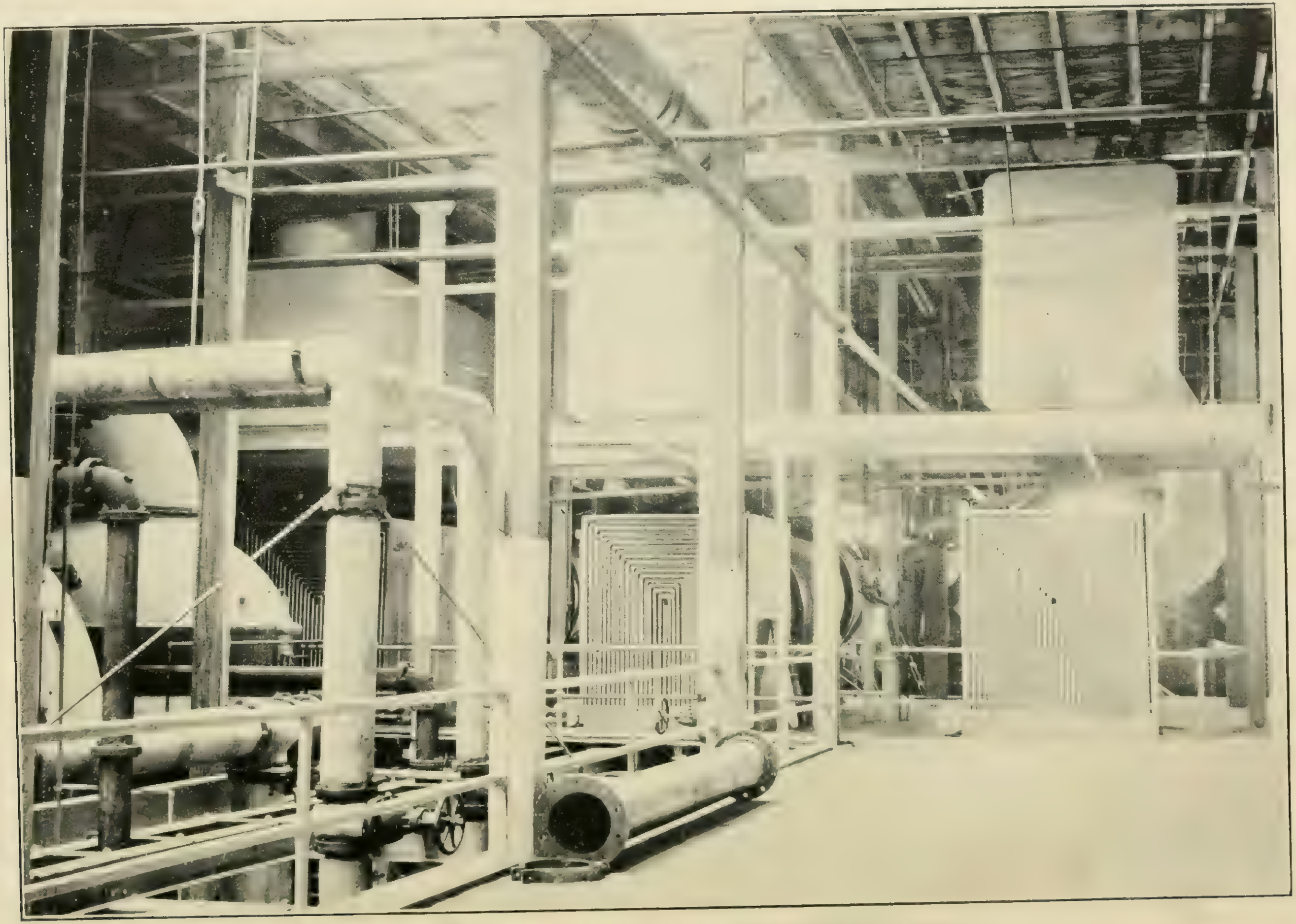
### FINAL DRYING OF CRYSTALS

For some reason not well understood, the next step in refining is called "granulation." Actual granulation, or crystallization, takes place in the pans, and the process about to be described should properly be called drying. The manufacturing term, however, is as given.

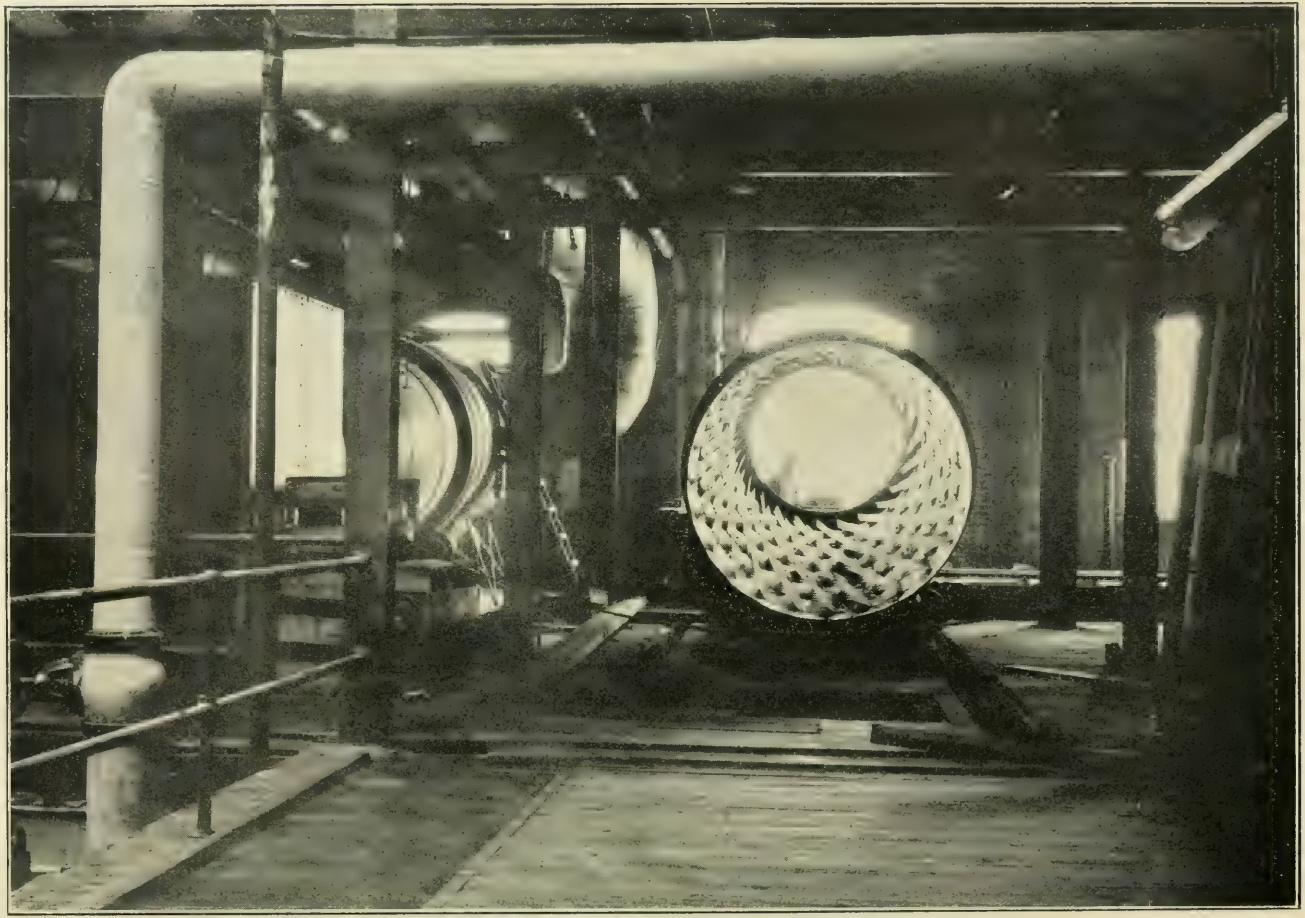
Drying is effected in an apparatus consisting of two large cylindrical drums of wrought iron. These drums are about six feet in diameter, thirty feet long and have a slight downward pitch from the receiving to the discharging end. The first drum rests on the floor, directly below the storage bin, and is called the sweater. It turns slowly on revolving wheels, by means of circular tracks bolted to it. The power that moves it is delivered from an electric motor, through a pulley, shaft and pinion, the latter working in a gear bolted to the outside circumference of the drum. Fastened to the inner surface of this drum is a series of short, narrow shelves with saw-tooth edges that serve to carry the sugar to the top of the revolving cylinder, whence it falls to the lower side, causing a continual shower of sugar throughout the entire length and breadth of the drum. The sugar is delivered through a pipe at the upper end of the sweater, and the revolving motion together with the incline of the cylinder gradually works it down to the lower end. Here it drops through a chute to the granulator on the floor below, where the process of drying is completed.

A strong current of hot air is drawn through the sweater by a powerful fan connected to the upper end by a very large pipe. The air introduced in this way is brought to a high temperature by passing around a number of coils of pipe charged with steam, which are placed directly in front of the sweater. The hot air sweeping through the drum absorbs nearly all of the moisture in the sugar, which carries 1.2 per cent of water when it enters the drum and about 0.1 per cent as it leaves it.

The granulator, or lower drum, is the same size as the sweater and is constructed in very much the same manner, having shelves for carrying the sugar to the top and dropping it at the proper point, and being equipped with a large fan to draw off the hot, moist air. Instead of having steam coils in front, however, it has in its center a steam-heated drum about twenty-



FRONT VIEW OF SWEATER—SHOWING STEAM COILS FOR HEATING THE AIR



INTERIOR VIEW OF SWEATER

four inches in diameter that revolves with it. The sugar crystals, as they fall in a shower from the shelves, come in contact with the hot inner drum on their way through the granulator, and in this manner become thoroughly dried. The moisture in the sugar, as it emerges from the granulator, is less than four-hundredths of one per cent, an amount too slight to determine except with the most delicate apparatus.

To insure perfect drying, the damp sugar must be fed to the upper drum or sweater with unfailing regularity. This is accomplished by the use of revolving screws located under the storage bins. By turning a certain number of revolutions per minute, they deliver an even and steady supply of sugar.

From the granulators the sugar is dropped on thin cotton belts that, passing around highly magnetized pulleys, carry it to the dry storage bins. The sugar is cooled to normal temperature before being packed in containers, thus preventing subsequent absorption of moisture and consequent caking.

Magnetic pulleys are used to extract any particles of iron scale or rust that may drop into the sugar after the liquor leaves the char filters. Rust sometimes forms in the pans, mixers, conveyors, elevators, sweaters or granulators, and should it get into the sugar the magnetic pulleys will surely remove it.

Storage bins and storage tanks are prominent accessories of all sugar refineries, for if a breakdown should occur at any point, there must always be a supply of material on hand to keep the refining operations going while the trouble is being remedied.

## SCREENING

### SEPARATING CRYSTALS INTO VARIOUS SIZES

The now thoroughly cold, dry and free-running granulated sugar is drawn from the storage bins through galvanized metal pipes and taken to the separators by screw conveyors, which deliver it at an even, steady feed—a most essential feature. The

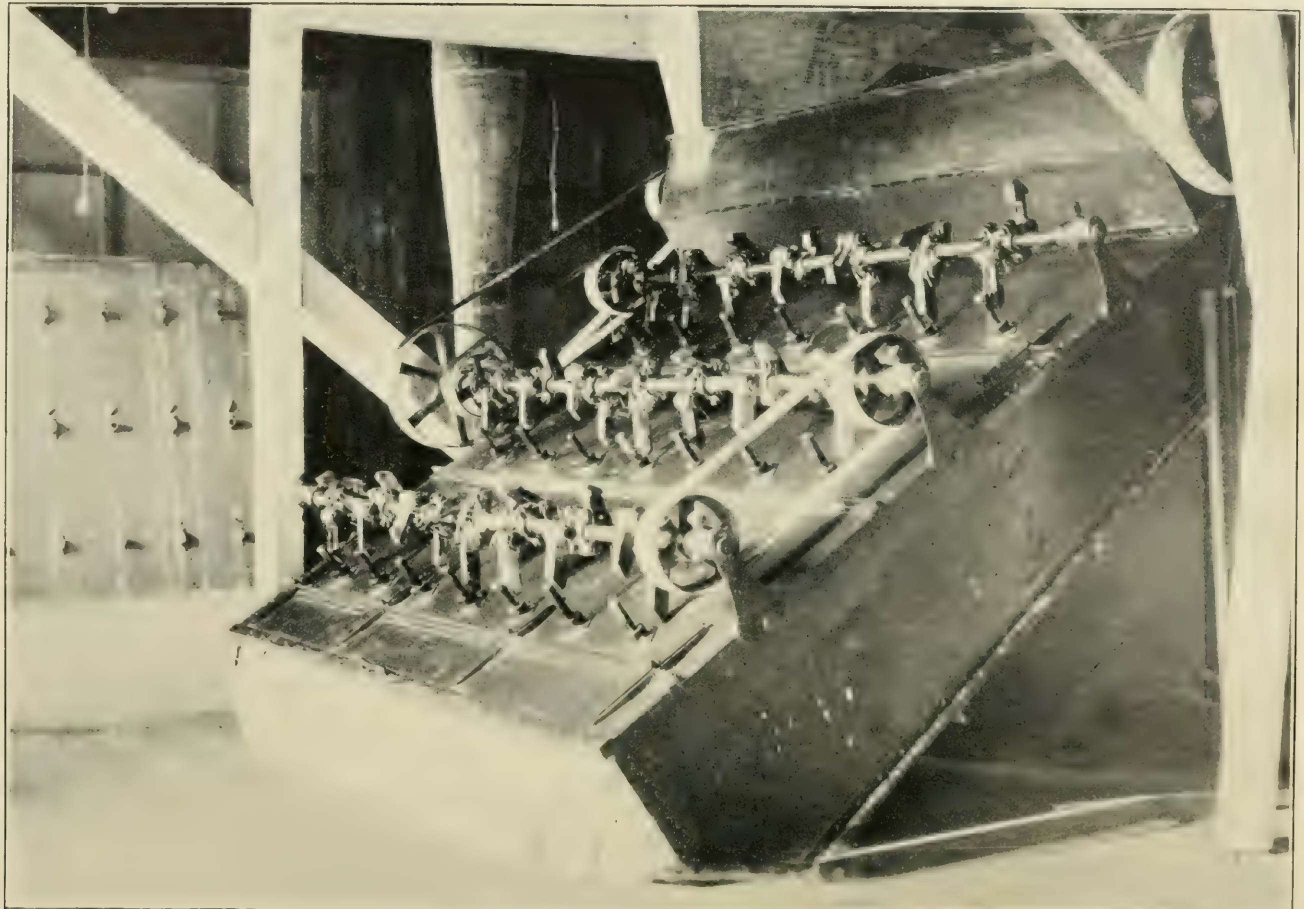
sugar as it comes from the pans is made up of crystals of various sizes. It also contains a number of small lumps formed in the centrifugal machines, or in some part of the process after it leaves the pans. It is necessary to separate the crystals according to size and to screen out the lumps, for the following reason:

In some parts of the country, people have been educated to use a coarse-grained sugar; in other sections, they are accustomed to sugar of a fine grain. For example, on the Pacific coast, the demand is for the fine-grained article; the consumers of the Mississippi river valley like a fairly large grain; while the Atlantic coast trade calls for a still coarser product. There is a difference, too, as to containers. In the East the preference is for the barrel package, while the Western buyer wants his sugar put up in bags.

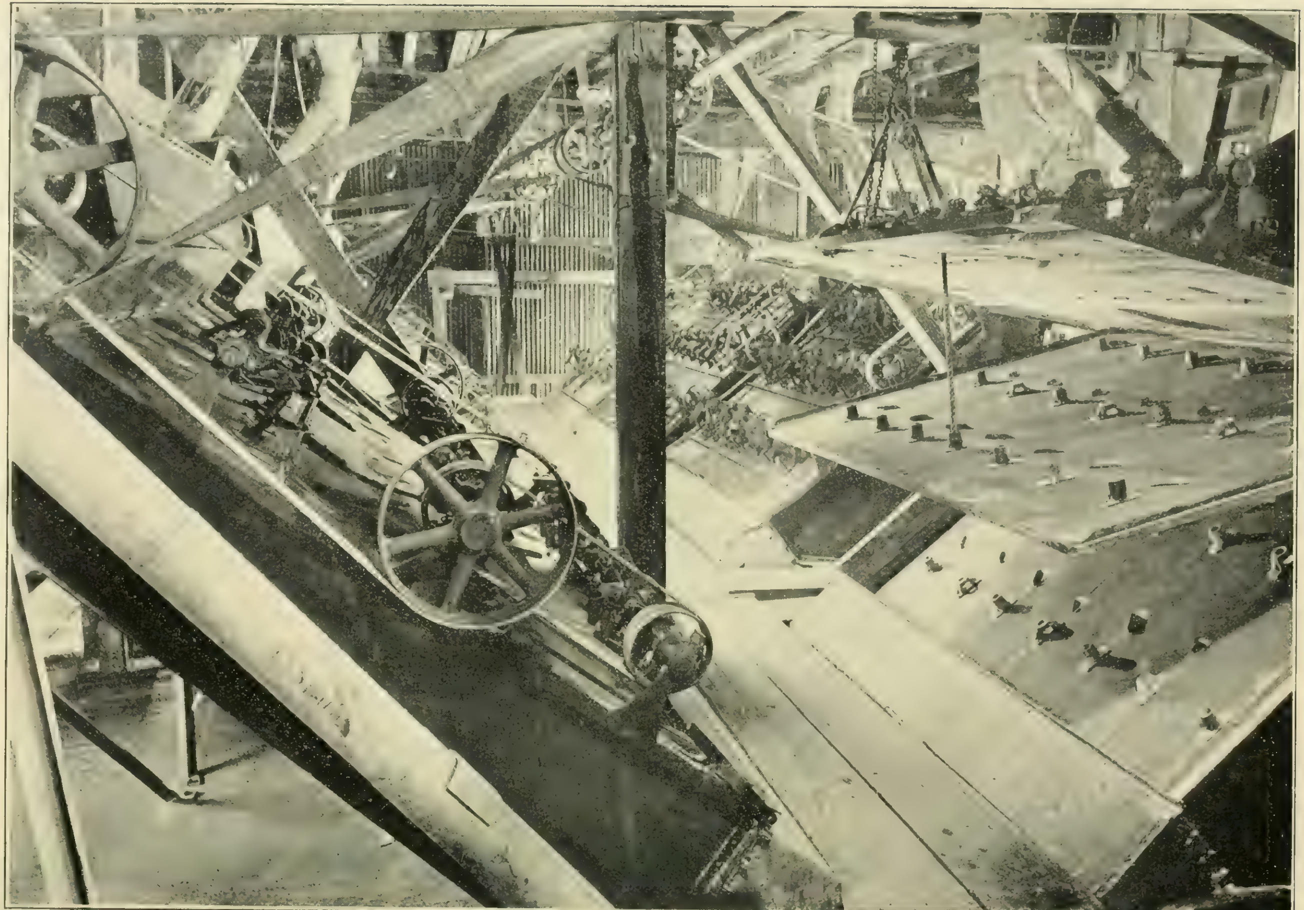
There are many different types of separators commonly in use, but in all of them the governing principle is the same. It is the elimination of lumps and dust from the final product and the separation of the sugar crystals according to size. The separator here specifically referred to will explain the principle as well as any other type, and a glance at the accompanying illustration will give the reader a good idea of its construction. It is made up of a number of wire screens of various sizes, fixed at a sharp incline, one above the other, and all enclosed in a tight, dust-proof steel case. At the top of the case is a steel screw conveyor by which the sugar is fed evenly and steadily across the entire width of the top screen.

On the outside face of the case are a number of shafts to which hammers are attached. As the shafts revolve, the hammers tap the various screens below, lightly and at rapid intervals, thus causing them to vibrate.

The upper screen, called the scalper, is quite coarse and allows all the sugar to fall through except the lumps, which



SEPARATOR—CLOSED, READY FOR OPERATION



SEPARATORS, ONE OF WHICH IS OPEN—SHOWING THREE SCREENS FOR SEPARATING THE SUGAR GRAINS

run down the face of the screen into a pipe that carries them to the melt, where they begin the refining process over again. These lumps, however, represent a very small proportion of the whole.

The second screen is finer than the scalper. It permits part of the sugar to pass through, but retains a certain amount which falls down on the face of the screen, whence it is led through a pipe to a special bin. Sugar of this size is known as coarse granulated.

The next screen lets the finer grains drop through, but catches the standard granulated, which in turn is drawn off to its special bin. The last screen, an extremely fine one, retains the extra fine granulated, and this in turn is delivered to its appointed bin. The sugar passing through the last screen is so fine as to be classed as "dust," which, not being marketable, is usually remelted.

The amount of any one grade of sugar obtained from the separator may be changed, within certain limits, by the boiling in the vacuum pans. If a large proportion of fine-grained sugar is required, the sugar boilers are instructed accordingly. It is impossible, however, to boil all the grains in each strike a uniform size, or to boil any two strikes exactly alike, so the separators are necessary, especially for removing the lumps and dust. The dust is caused by the constant falling of the dry sugar crystals against each other in the driers and granulators, and by the grinding action upon the sugar crystals in the screw conveyors.

## PACKING

### FILLING VARIOUS KINDS AND SIZES OF CONTAINERS

When putting up his goods, a sugar refiner—like every other manufacturer—must needs cater to the wishes and tastes of the consuming buyer. The modern tendency in containers is in favor of sealed air-tight and dust-proof packages. Some refiners

spend great sums of money every year in advertising the merits of special sugars packed in dust-proof cartons. Their rivals generally follow suit, as competition in the marketing of sugar is probably far keener than in any other line of business.

The plain truth is that all refined granulated cane sugar offered for sale in the markets of this country today is almost identical, irrespective of the manner in which it may be packed. The poorest quality of refined sugar made has, in all likelihood, a purity not lower than 99.5 per cent, while the highest grade cannot possibly exceed 99.9 per cent, a difference of only four-tenths of one per cent, hence it is evident that all refined sugars are practically pure, the fancy package simply meaning a fancy price.

The methods of transporting and handling the sugar after it leaves the refinery may justify the additional expense, but this is subject to argument. However, it makes but little difference to the manufacturer, as the cost of the package as well as the extra handling is always included in the selling price.

A few years ago all sugar went out in barrels or bags, while today a modern refinery turns out about twenty different styles of container, and twenty-four kinds of sugar. It is obvious, therefore, that the packing room of a refinery is an interesting place, covering as it does a large area and including a great amount of special, intricate machinery for filling, weighing and sewing or sealing packages.

In the bottom of the bins into which the sugar is delivered from the separators is a series of galvanized iron pipes, through which the sugar runs to the various filling devices, the latter being usually arranged in long rows. Under the end of each pipe is an automatic weighing machine. In packing bags, a workman hangs a bag on the weighing machine and presses a lever, thus allowing the sugar to run into the bag. As soon as the exact amount required is reached, the flow is automatically cut

FILLING, WEIGHING AND SEWING 100-POUND SACKS


FILLING, WEIGHING AND SEWING 25-POUND SACKS

off. These weighing machines are so accurate that they gauge the amount to within a fraction of an ounce. The operative removes the full bag, places it on a conveyor that runs in and level with the floor and quickly adjusts an empty one on the weighing machine. These men become so expert that a single operative will fill two hundred and fifty one-hundred-pound bags per hour. The weighing machines are designed to fill and weigh four hundred and eighty one-hundred-pound bags per hour, but the operative cannot handle them at this rate.

Four sewing machines, specially designed for sewing the filled bags, are located immediately over the conveyor and in direct line with it. As the bag passes along on the conveyor, the operative at the first machine picks up the end of the inner cotton sack and passes it through his machine, stitching it securely. The bag then passes along to the third machine, where the operative takes hold of the outer burlap bag and sews it in the same manner. Each operative has a spare machine ready for instant use in case the one he is running gets out of order. Continuing its journey to the end of the conveyor, the bag is deposited on the main belt conveyor, which takes it without manual aid to the shipping floor or the storage warehouse. A sewing-machine operative will sew as many as seventeen bags per minute, but it is trying work and the men relieve each other at intervals during the day. Both the one-hundred- and the forty-eight-pound sacks are handled in this manner. Formerly the half sacks weighed fifty pounds, but since the Parcel Post law went into effect they have been changed to forty-eight pounds to permit of their shipment by mail. Those containing twenty-five, ten, five and two pounds are weighed and sewed in much the same way, by the aid of specially designed, rapid-handling machinery. The small package machines will accurately weigh and fill five-pound bags at the rate of twenty-five packages per minute, the others in proportion.

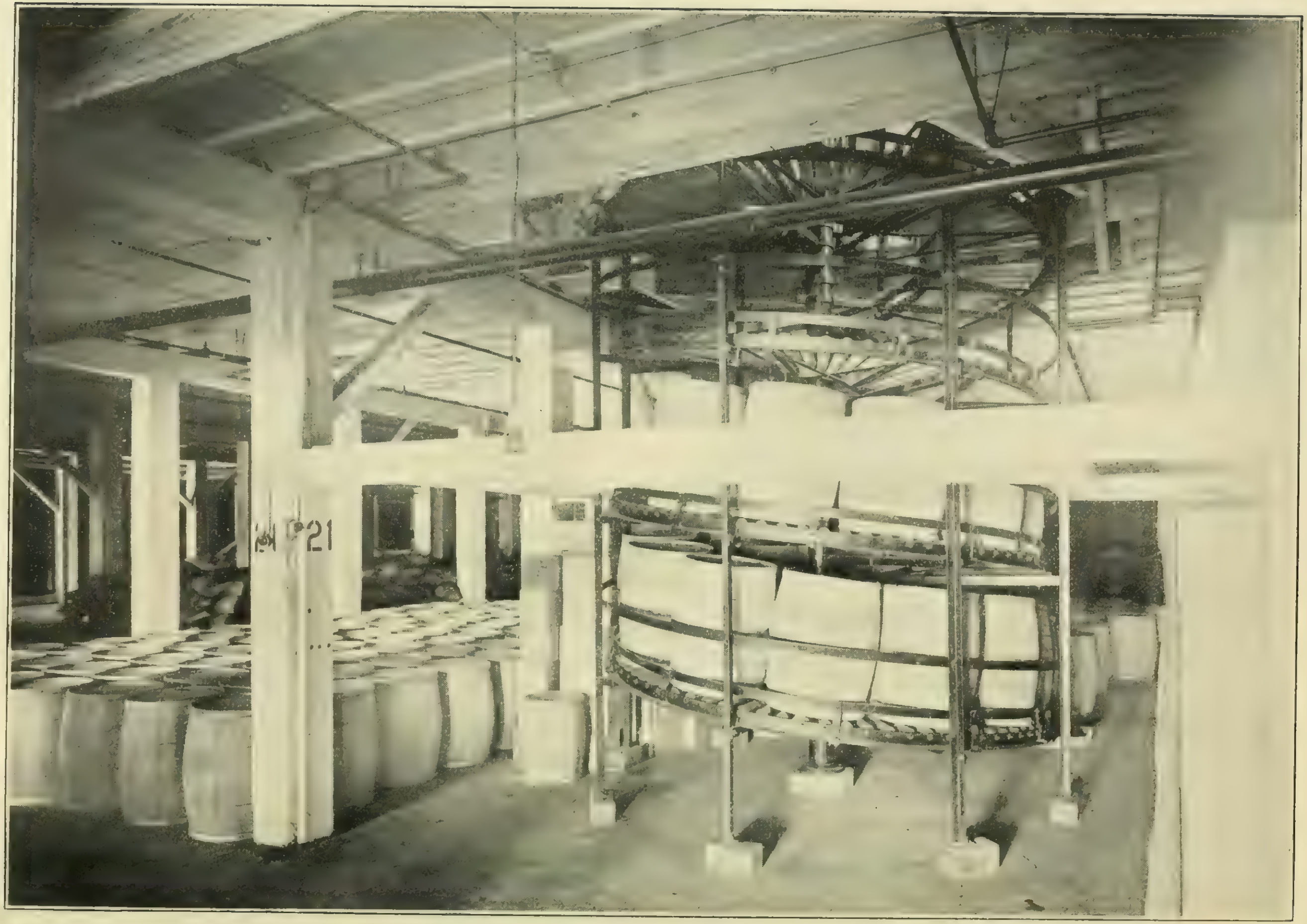
The paper boxes, or cartons as they are called, are weighed and filled by special machinery. This machinery seems to possess an intelligence almost human. One girl feeds the cartons (the tops and bottoms of which are open) into the machine at the rate of thirty-two per minute. The machine glues the bottom, weighs the sugar to within one thirty-second of an ounce, fills the carton, glues the top, seals it and passes it on to a conveyor which delivers the finished package to a table, from which it is packed into a box for shipment. Women are usually employed in putting up the lighter packages.

A short distance from the bag-weighing machines, and running parallel with them, is a line of pipes or spouts for filling barrels. On the floor under each spout is a barrel shaker. This is a heavy cast-iron plate that is lifted about one inch, first on one side, then on the other, by the action of two cams or arms attached to a revolving shaft underneath. The shaker drops back violently on the supporting frame after each lift, causing the sugar to settle compactly in the barrel as it is filled to an average weight of three hundred and fifty pounds. Naturally, the greater the amount of sugar packed in a barrel, the less the container costs per unit of output, and as the average cost of a sugar barrel in the United States is fifty cents, the container cost per one hundred pounds of sugar is 14.3 cents.

Without the shaker, not more than three hundred and thirty pounds of sugar could be put in a barrel, which would increase the cost per one hundred pounds to 15.1 cents. This difference on a single day's output of two million pounds represents one hundred and sixty dollars, an eloquent argument in favor of the shaker.

In packing barrels, the operative first lines the barrel with heavy paper to prevent the sugar from coming in contact with the rough wooden sides and to keep it from sifting out between the staves. The barrel, thus lined, is placed on the shaker,


FILLING BARRELS



METHOD OF HANDLING BARRELS

a valve on the spout opened and the shaking barrel filled to the top. The barrel is then removed and turned over to the cooper, who heads it up and rolls it on the scale for weighing.

Before an empty barrel reaches the packing room, it is weighed and the weight (generally from nineteen to twenty-five pounds) is stamped on its side. The gross weight of the filled barrel is determined by the packing-room scales. The weight of the empty barrel is deducted and the net weight of the sugar stenciled on the head. The full barrel is then sent down a chute to the waiting freight car or to the dock for steamer shipment, or to a conveyor that automatically delivers it to the storage warehouse.

In addition to the bags, barrels, half barrels, cartons and boxes, tins of various sizes are used for the different sugars. All of these are filled and weighed automatically, and taken from the packing room by conveyors. Some of the boxes are lined with paper and some with cotton cloth; some are nailed up in the ordinary way, and others are strapped with iron at each end. As a rule, the individual tins are cased with wood, but sometimes there are a number of tins in a case. Cartons contain two pounds, three pounds or five pounds of sugar. They are packed in fiber cases holding thirty twos, twenty threes or twelve fives and also in wooden cases which hold sixty twos, forty threes or twenty-four fives each. The style of package depends upon the demand of the trade catered to.

At this point a word or two about some of the specialties, such as cube, powdered and bar sugars, as well as yellow or soft sugars, may be of interest.

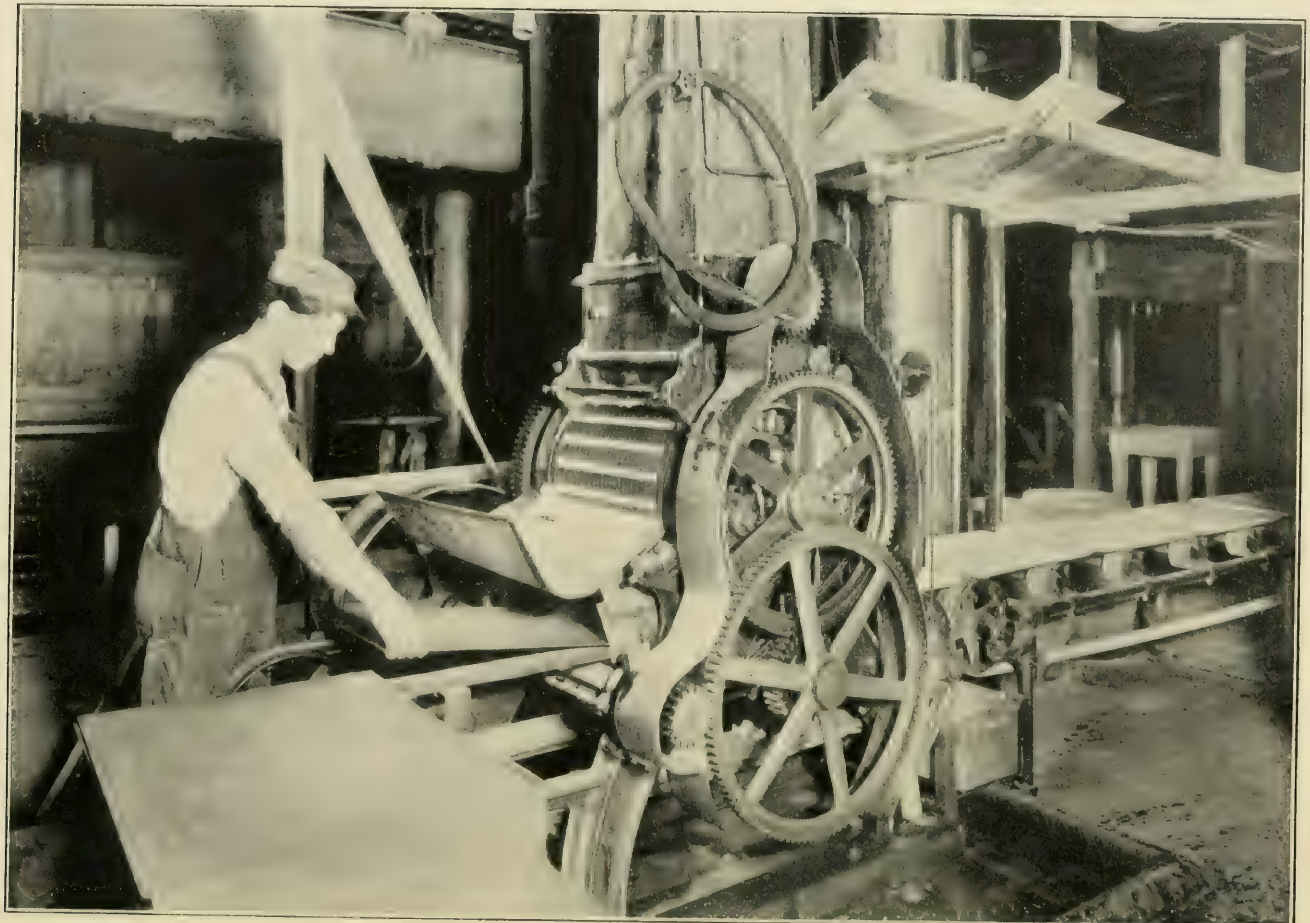
### CUBE SUGAR

The sugar from which the cubes are made is of a rather fine grain, boiled in special pans from liquor that has been filtered over the char at least twice. From the centrifugals under the

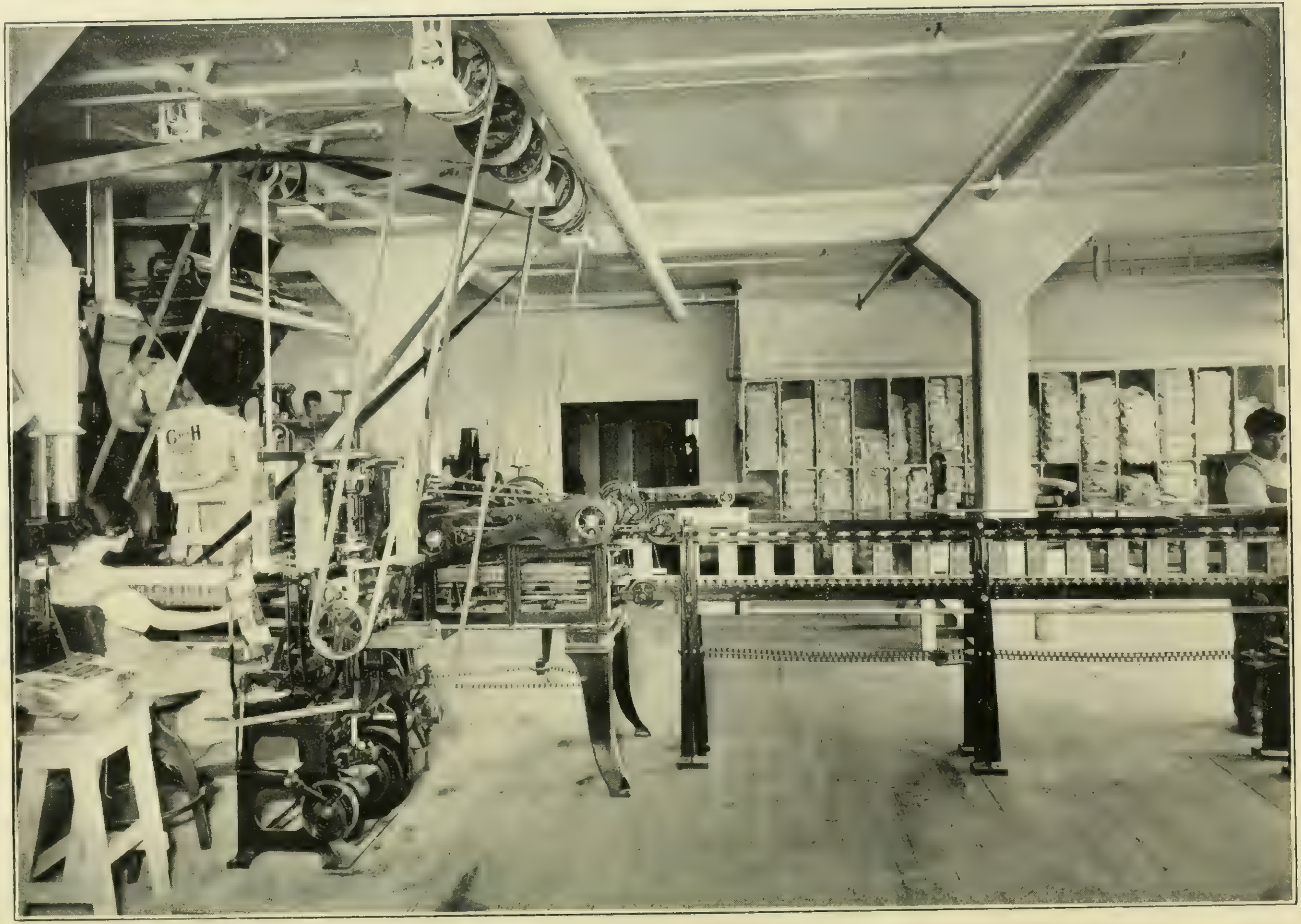
pan it falls into a hopper in which there is a revolving screw. Directly over the screw is a tank containing a warm, white sugar liquor, very sticky and viscous by reason of its density. A pipe leads from the bottom of this tank to a point over the screw, and the liquor, which is controlled by a valve, is allowed to drip upon the sugar. The action of the screw causes the sugar and the liquor to become thoroughly mixed and feeds the damp mass thus formed into a spout leading to the cube press, the machine in which cube sugar is made.

At the top of this machine is another hopper, into which the damp sugar drops from the spout overhead, and revolving in the last-mentioned hopper are a number of small shafts with brass pegs inserted at certain intervals along the length of the shafts, like spokes in the hub of a wheel. These pegs are like human fingers in their action and they press the sugar down into the pockets of a large revolving drum placed directly under the hopper. Each pocket is the size of a cube or half cube. Working in these pockets are plungers, which fall back as the revolving drum reaches the highest point directly under the mechanical fingers in the hopper. The fingers fill the open pockets and, as the drum turns, the plungers, at a certain point in its circumference where a heavy bronze bar is placed across its face, slowly enter the pockets and in so doing compress the sugar into cube form.

Two belts run through the machine under the cylinder, carrying galvanized iron plates about twenty-four inches wide, or the same width as the cylinder, and thirty inches long. As the line of pockets into which the sugar has been pressed reaches the lowest point on the circumference of the drum, the plungers drop down, forcing the pressed cubes out of the pockets onto the galvanized iron plates which the moving belt carries along out of the way of the next lot coming from the cylinder. Each plate, as it leaves the cube press, contains five hundred and four



CUBE-SUGAR MACHINE




CARTON MACHINE

cubes and one hundred and sixty-eight half cubes, and the time required to fill a plate is between six and seven seconds.

The belts carry the plates to a series of ovens, or driers, so placed that a large number of plates with their contents may be inserted through a door on the belt side. When the ovens are filled with plates holding the soft, moist cubes, a current of hot air is turned on at the top of the ovens, passing out at the bottom. The hot air circulating in this manner dries the cubes and carries off the moisture. Eight hours in the ovens suffice to render the cubes thoroughly dry and hard. They are then removed through doors opposite to those through which they were put in. This arrangement prevents the men who are putting the cubes into the ovens from interfering with those taking them out, for the process is a continuous one and cubes are placed in and removed from the ovens at the same time. As the cubes are taken out of the ovens, they are deposited on a belt conveyor which delivers them into bins in the packing room, ready to be put into boxes, bags, barrels and other containers.

## POWDERED AND BAR SUGAR

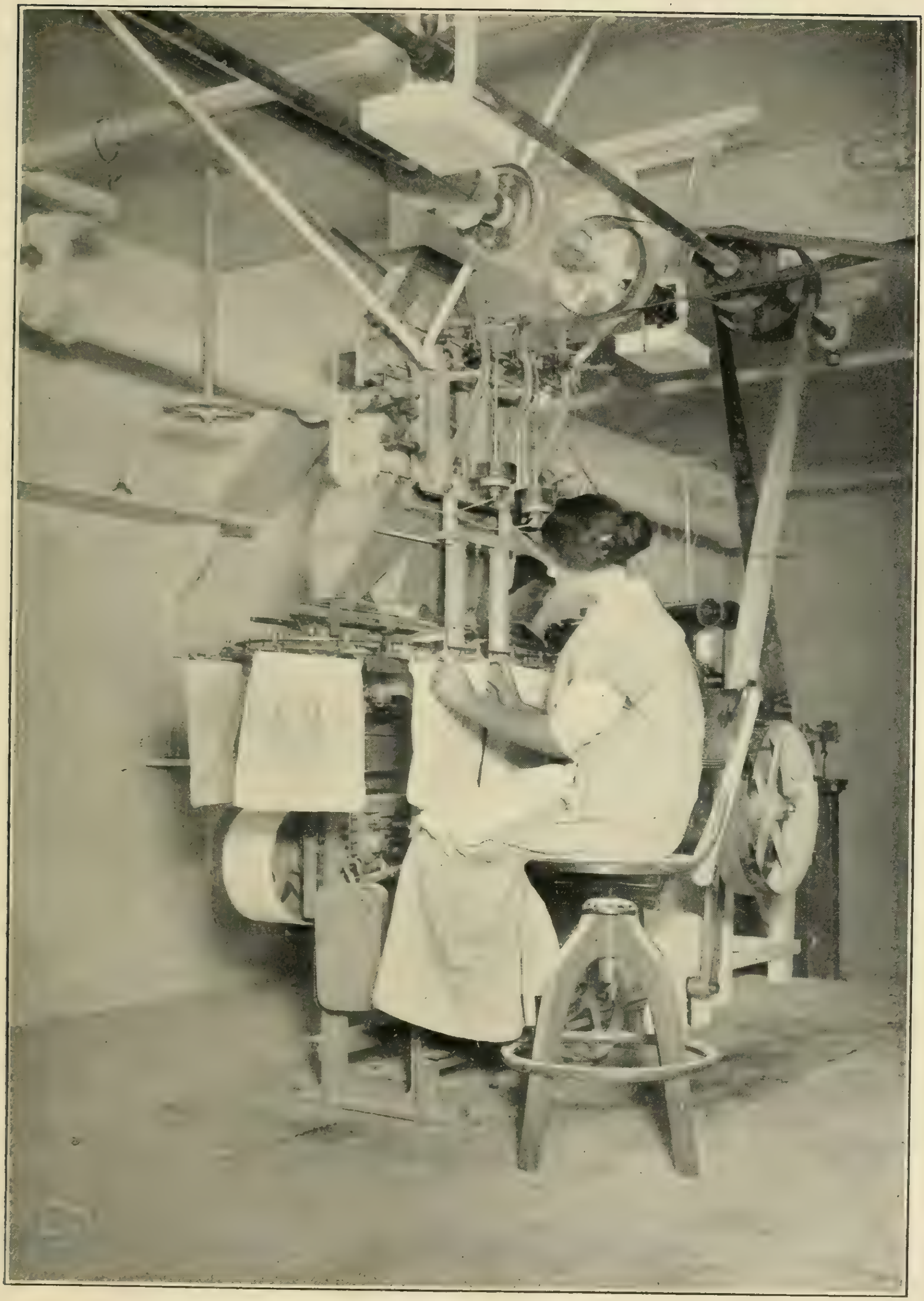
Powdered and bar sugars are made by grinding coarse granulated sugar into fine particles and then separating these particles by screening them through fine silk cloth. The bolting of flour is a similar process. Powdered sugar has a decided tendency to cake and become hard, and the coarse sugar from which it is ground should be particularly free from moisture. After being crushed or ground between corrugated rolls turning at high speed, the ground sugar passes into a screening or sifting device, of which there are many kinds in use, the most common being the horizontal, revolving centrifugal screen. The crushed sugar goes in at the head end, and, as it enters, a number of revolving arms throw it against a silk screen on a circular frame,

revolving in an opposite direction, that permits the finest, or powdered, sugar to pass through a silk cloth having over sixteen thousand openings per square inch.

The powdered sugar extracted, the remainder drops into another screen where a similar sifting action takes place, the silk of the second screen being coarser than that of the first, and bar sugar is the result. Such grains as are too large to pass through the bar screen are carried back to the rolls and reground. The bar screen has about five thousand openings per square inch.

Bar sugar, as the name implies, is generally used in preparing beverages. It dissolves almost instantly when dropped in water. Singularly enough, the average housewife is not aware of the advantages attending the use of this grade of sugar. It does not become caked as readily as powdered sugar does, and is the ideal sweetening for berries and cereals served at the breakfast meal. It is far more desirable than powdered sugar for most of the purposes for which the latter is commonly used.

It is believed by many that *all* powdered sugar is adulterated with chalk, starch, white corn meal or similar substances. Such is not the case, and it is safe to assume that no mixing whatever is done by any refiner in America. Powdered sugar has a strong tendency to cake or become hard, and some manufacturers who buy coarse granulated sugar from the refiners for grinding purposes use starch to the extent of from two to three per cent. Chalk is never used, nor are other non-edible or deleterious substances. Starch is not introduced for the purpose of making a greater profit, but to prevent the powdered sugar from caking. The adding of starch, in all probability, increases the cost of making powdered sugar, as starch costs almost as much as sugar, and the expense of handling it and feeding it into the grinding machinery is quite an item.



FILLING, WEIGHING AND SEWING 2-POUND, 5-POUND AND 10-POUND BAGS

### YELLOW SUGARS

Yellow sugars, or "softs" as they are usually called, comprise fifteen grades, ranging in color from a creamy white to a dark brown. These sugars are used chiefly by bakers in making ginger-bread, pies and cakes, although a small quantity finds its way directly into households for ordinary domestic consumption.

The characteristics of yellow sugars are that they have a small grain and contain a sufficient amount of molasses to make them moist to the touch, properties brought about by a radically different method of boiling from that applied to white sugars. They also contain a certain amount of invert sugar which preserves the softness of grain and prevents subsequent caking or hardening.

To properly explain how yellow sugars are boiled, reference must be made to the method of boiling white sugars, which may be briefly summarized as follows:

The object to be attained in boiling white sugars is the separation of the crystallizable sucrose contained in a given solution from the impurities, moisture and non-crystallizable content of that solution. The formation of sugar crystals is a natural result of the evaporation of the moisture from the liquor or solution. In order to obtain pure white crystals, it is vitally essential that, as far as possible, all impurities and non-sugars, except water, be removed from the liquor before the boiling takes place, for if the coloring matter is not thoroughly taken out, obviously the crystals will be colored. The purifying and decolorizing operation is accomplished in the char filters. After the grain is once formed in definite crystals, these crystals attract and appropriate the sucrose in solution in the process of building up their structure, while repelling or excluding the impurities, so that in consequence the latter remain in solution. Irrespective, however, of whether crystallization of sucrose takes

place in solutions of high or low purity, it will only partially remove the sucrose from the solution in one operation, the limit being fixed by the amount and nature of impurities present. In order to bring about further crystallization of sucrose the solution or mother liquor surrounding the crystals must be separated from them and be again diluted, filtered and concentrated.

Briefly, the procedure in boiling white sugar in a vacuum pan is to take liquors of the highest purity for the first boiling. After the first crystals have been removed from the mother liquor in the centrifugal machines, the liquor is again diluted, decolorized by bone-char and boiled to grain. This operation is continued a number of times, the purity of the liquor decreasing each time. Finally, when the purity of the liquor falls to a certain point, the boiling is discontinued, for at this point conditions do not admit of further formation of pure sucrose crystals, and, if the process were pursued further, the resulting sugar would not be white. Therefore, when this state is reached, these low-grade liquors are boiled into a semi-refined sugar, commonly called "refinery raw," which corresponds fairly closely in test with the original raw sugar, or they are used for making soft yellow sugars as explained later on. This refinery raw is then washed, melted and put through the whole process all over again. The liquor, from which the crystals formed in repeated boilings have been removed as made, at length becomes so charged with impurities that further crystallization of sucrose is impossible and this residue, or final waste, is known as blackstrap molasses.

This manner of boiling white sugar has been called the "out and out" method, in contradistinction to the "in and in" method employed in boiling soft yellow sugars, of which a few words of explanation now follow.

In boiling soft yellow sugars, the aim is to produce a large number of small sucrose crystals having the property of at-

tracting and combining with the molasses content of the liquor and that will retain some of the molasses after they are purged of mother liquor in the centrifugal machines. This process gives a sugar that may be described as a mechanical mixture of sucrose, invert sugar and the non-sugars in the molasses.

In the case of yellow sugars, the lighter the color the better price they bring. The greatest profit, therefore, is derived from the manufacture of sugars of the lightest color and carrying a reduced percentage of sucrose. In boiling such sugars, low-purity liquors from which the coloring matter has been removed as far as practicable by bone-char filtration are required. For the purpose, it is generally found most advantageous to use the liquors taken from white sugar massecuite at the point when, owing to repeated boilings, its purity has fallen so low that further extraction of pure white sucrose crystals is impossible.

As a result of the numerous filtrations through bone-char preparatory to reboiling in the manufacture of white sugar, these liquors are usually lighter in color than any of corresponding purity obtained in the refining process. Nevertheless, they are not necessarily the only liquors suitable for the purpose, and this particularly applies to the making of the lower grades of yellow sugars. It is, however, beyond the scope of this book to elaborate upon that phase of sugar refining. The object sought here is to give a general idea of how yellow sugars are boiled, without going into all the details.

As is the case with white sugars, yellow sugars are made by a succession of boilings in vacuum pans, the liquor used for each boiling or strike being that obtained from the massecuite of the previous strike. The operation is continued until the liquor becomes too low in purity and dark in color. Each successive strike boiled is lower in test than the preceding one, due to the fact that the sucrose crystals represent the purest part of the massecuite, and, consequently, each time they are removed

the quality of the liquor is lowered. This accounts for the various grades of yellow sugar that are made, fifteen in all, starting with a creamy white and ending with a dark brown. The sucrose content of the best is about 92 per cent and that of the poorest about 80 per cent.

In making white sugars, the aim is to produce from liquors of high purity sucrose crystals that are pure white, hard and absolutely free from molasses.

In making yellow sugars, the object is to boil from low-purity liquors soft sucrose crystals that possess the property of attracting and retaining the molasses and to make this combination of crystals and molasses as complete as possible.

The essential difference between the two methods, as well as the appropriateness of the descriptive terms "out and out" and "in and in," will be readily apparent.

The impurities in yellow sugars are natural and consist of invert sugar, glucose, organic non-sugars and salts, all of which were originally present in the raws or were formed in the process of refining.

It is not unusual to hear it said that yellow sugars are sweeter than granulated. To the average palate this is apparently so, but, as has been shown, granulated sugar contains 99.8 per cent of sucrose or sweetening matter, while the highest grade of yellow carries only 92 per cent. Soft sugars dissolve more readily on the tongue than granulated, and the syrup or molasses in them accentuates their sweet taste.

There are several other grades of sugar prepared for the consuming market, but lack of space precludes a description of them or the methods by which they are produced.

### MECHANICAL DEPARTMENT

It is needless to say that the conveying, melting, filtering, boiling, drying, screening, weighing and packing of one thousand

tons of sugar in twenty-four hours necessitates a great amount of steam and a multiplicity of machinery.

The boilers generate steam to drive huge pumps that deliver cold salt water to the condensers throughout the refinery, to drive vacuum pumps that make boiling and evaporation *in vacuo* possible, and to drive large turbine or reciprocating engines that supply the electric power. The exhaust steam as it leaves the cylinders has a pressure of about fifteen pounds per square inch. It is conducted through pipes to the evaporators, pans, driers and tanks, where it is again used for concentrating the liquors, boiling in the pans, drying the sugar and keeping the liquors hot throughout the process. It leaves the various heating coils and tubes as hot water and is returned to the boilers for the generation of more steam.

Live steam, that is to say, steam just as it comes from the boilers, is used extensively in the vacuum pans for boiling the liquor to grain.

A refinery melting one thousand tons of raw sugar each day requires about 5500 boiler horse power. On the Atlantic coast coal is the fuel used, while on the Pacific coast oil is burned. The amount of fuel consumed in different refineries varies to some extent, but a fair average per ton of raw sugar melted is one and one-third barrels of oil, or one-third of a ton of coal.

In modern plants all the moving machinery, except the pumps and main engines, is usually driven by electric motors. This does away with many dangerous belts, as well as expensive transmission machinery. The motor drive is simple and efficient and therefore used extensively.

The mechanical department is under the general supervision of the superintendent, but in direct charge of a mechanical-electrical engineer. This man is known as the chief engineer, and he is directly responsible, not only for the operation of all the machinery in the plant together with its up-keep and repair, but

he has also to cope with engineering problems that are constantly arising. Under his direction, a corps of draughtsmen is always busily engaged in planning and designing improvements and additions. He also maintains a force of mechanics, watching, operating and repairing the machinery. These men represent almost every trade, including machinists, blacksmiths, coppersmiths, tinsmiths, millwrights, boilermakers, riggers, masons, painters and many others.

The diversity of the mechanical work around a refinery is remarkable, and the engineer in charge must be a man of exceptional mechanical ability, as his duties include not only steam, electrical and civil engineering, but construction engineering of an advanced character. As refineries are always built on sites bordering on deep water, harbor engineering problems are also constantly before him.

In connection with every refinery there are many shops, where mechanical work incidental to repairs and construction is carried on. These shops are equipped with the necessary tools and implements for quick repairs and are under the supervision of the chief engineer. In addition, there is the cooper shop where many thousands of barrels are turned out daily, and the bag factory where twenty cotton bags and twenty burlap bags must be made for each and every ton of output packed in that manner.

The mechanical department of a modern refinery is as important as it is extensive, for failure in any one of its branches means costly delays. The machinery is run twenty-four hours each day, except Sundays, during about eleven months in the year. The plant is closed down the remaining thirty days for annual cleaning and repairs.

Intelligence and ability, tempered with good judgment, bring about the *esprit de corps* that gives the necessary results. The mechanical is almost as important as the chemical depart-

LABORATORY

OIL-BURNING BOILER PLANT

ment and, as before stated, it is subject to the general supervision of the chemical engineer.

## LABORATORY

The chemical laboratory is really the heart of the institution, for upon it depends the success of every manufacturing operation. The superintendent of a refinery must possess a thorough knowledge of chemical engineering, for the process of sugar refining is largely chemical from beginning to end.

Competent chemical engineers, as distinguished from chemists, are rare, and yet their calling offers more promising prospects to young men than most other professions do today. It is clear to the intelligent observer that in these times of intensely keen competition, the manufacturer will, sooner or later, inevitably be driven to seek a considerable percentage of his profits in the utilization of by-products that now go to waste or bring but little return. The men to solve the manufacturing problems of the future will be chemical engineers. Broadly speaking, comparatively little has been done in this field in the United States, and its possibilities are incalculable.

In the laboratory, day and night, a corps of chemists is constantly engaged in the study of questions that arise in connection with the operation of the various departments. Polarizations for account of buyers and sellers of all raw sugars purchased, are made and checked there; hundreds of samples of liquors and syrups are tested daily for control work, as the purity of both must be known at all times and a record kept of their temperatures and densities. Samples of all the sugars entering the refining process, as well as of the finished product, are carefully analyzed, and upon these analyses are based elaborate calculations regarding yield and efficiency. The wash waters from the char filters are examined and tested frequently, the bone-char is tested every twenty-four hours as a check upon

the process of revivification in the kilns, and once a month the bone-char is completely analyzed to determine the deterioration that has taken place in it.

Tests are made of materials used in the refining process, such as lime, soda, acids and lubricating oils; of the feed water for the steam boilers; of the fresh water used throughout the plant; and of the fuel, whether coal or oil. Even the gases from the fires under the boilers are tested as they pass through the smokestack, in order to determine whether or not the firemen perform their duties properly.

Taking all this in conjunction with frequent tests and experimental work on driers, condensers, evaporators and other apparatus, it will be seen that there is plenty to keep a large staff of chemists fully occupied.

In refinery work, what is to be feared more than anything is the house becoming "sour." Raw sugars and sugar liquors, and particularly the sweet waters, have a tendency to ferment, and fermentation, like fire, if not checked and brought under control before it gains much headway, soon pervades the entire establishment, affecting all the liquors and syrups, thus turning the sucrose or sugar into glucose, which cannot be recrystallized. In a refinery of two million pounds daily capacity, there is double this quantity of sugar in the house in the form of liquors, syrups, sweet water, massecuite and raws. If all of this four million pounds turned "sour," the money loss, with raw sugar worth four cents a pound, would be about one hundred and sixty thousand dollars. Such a contingency, while remote, clearly demonstrates that chemical control is an absolute necessity.

### COST OF REFINING

In concluding that part of the story that deals with refining, some reference may be made to the refining cost and to the price at which refined sugar is sold.

The cost of refining sugar varies in different parts of the United States on account of the difference in the cost of commodities entering into the refining process, such as labor, fuel, cotton, burlap, containers, bone-char, etc. On the Pacific coast nearly all these items are higher than in New York, and consequently the cost of refining is probably greater.

In 1911 nearly all the sugar refiners of the United States appeared before the Hardwick Congressional committee at Washington and the testimony given by them before that body showed that the cost of refining ranged from 60 cents to 65 cents per 100 pounds.

On the day the Congressional committee began its investigation, raw sugar was selling in New York for 3.86 cents per pound, and the testimony regarding the cost of refining was no doubt based on this price for the raw sugar entering the refining operations.

It is therefore fair to assume that under normal conditions, with raw sugar at about 3¾ cents, the average cost of refining in the United States is 62½ cents per 100 pounds. This includes every item from the time the raw sugar is landed on the dock until the refined is loaded on the cars or boats for shipment. It includes the selling and overhead expenses, but not the transportation charges after the sugar leaves the refinery.

During the last six years (1909-14 inclusive) the actual differential in the United States between the purchase price of raw sugar and the selling price of refined has been 82½ cents per 100 pounds. The difference between this figure and the cost of refining represents the refiner's gross profit; in other words, about 20 cents per 100 pounds, out of which he must pay for all additions and improvements to his plant. The remainder is available for returns on capital invested. This difference varies with the time of year and in different localities, but the average will probably hold good.

A refiner of cane sugar buys his raw product in the open market and must pay for all his operating and administration expenses and obtain his profit from the margin between the buying price of raw and the selling price of refined sugar. The cost of refining is not constant, as it varies with the fluctuating values of fuel, containers, labor, and particularly the cost of raw sugar. If it costs 62½ cents per 100 pounds to refine sugar with raws at 3.86 cents per pound, it will cost about 82½ cents per 100 pounds with raw sugars at 6 cents, assuming that such items as fuel, containers, labor, etc., remain constant. This is due to the greater value of the raw sugar lost in refining, to the heavier insurance premiums and higher interest charges. With high-priced raws, the margin between raws and refined must be proportionately greater to offset the increased cost of refining.

The refiner, like the consumer, would prefer to see sugar selling on a low basis, while the producer always hopes for the opposite.

## SHIPPING DEPARTMENT

HERE will be found every modern convenience for the rapid loading of cars and steamers. Adequate railway trackage is provided for the handling of shipments moving by rail, and on the waterfront side of the warehouses there is ample berth room for steamers that carry the sugar to cities and towns on the inland waterways and the seacoast, together with points tributary thereto. Facilities are also at hand for local delivery by drays.

Railroad cars are sometimes sent to refineries by water, on car barges, to be loaded with sugar and then towed to what are known as railroad terminals, where the cars are taken from the barges and started on their journey to destination. The capacity of a car varies from twenty-four thousand to one hundred thousand pounds. If an amount of sugar equal to that consumed in the United States in 1915 were loaded into cars containing 1000 sacks of 100 pounds each, it would require 81,087 cars, which would make up a train 768 miles long.

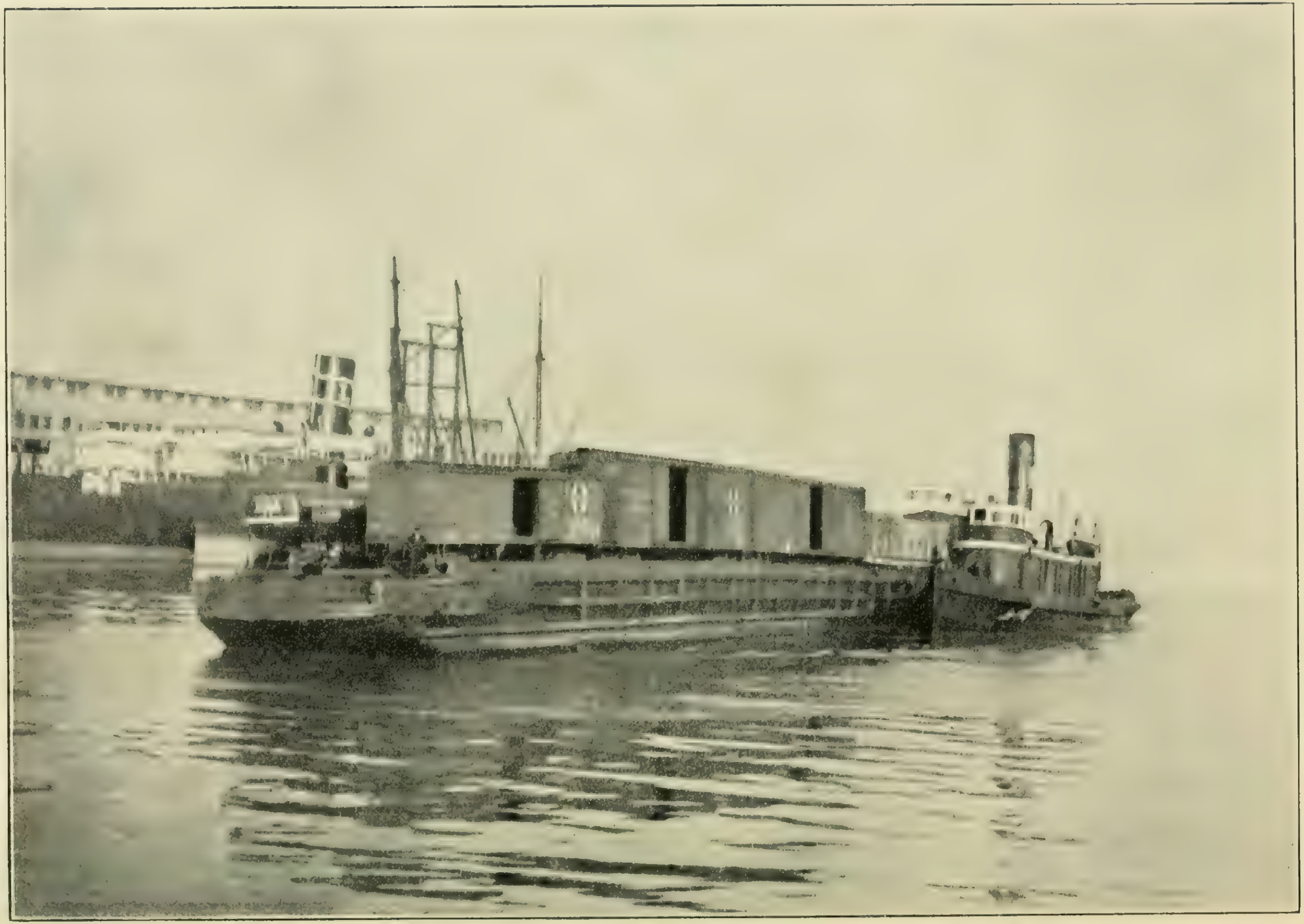
A large part of the product is delivered direct from the packing-room conveyors into the waiting cars and steamers, thus avoiding unnecessary handling. A single shipment frequently includes a number of different styles of package, and great care must be exercised to insure accuracy in count and description.

As dry granulated sugar readily absorbs moisture, every precaution must be taken to make the storage rooms thoroughly damp-proof, so that the sugar may always be in good condition when shipped from the refinery.

Shipments are made only on written orders from the sales department to the head of the shipping department. These or-

ders set forth the name of the buyer, the kinds and quantity of sugar desired, the point to which the sugar is to go, the route by which it is to travel, the date on which it is to be shipped, and the terms of sale. At the proper time the sugar is loaded, shipped, and in due course delivered to the buyer.

INLAND-WATERWAY STEAMER LOADING SUGAR AT REFINERY DOCK



CAR-FLOAT ARRIVING AT REFINERY DOCK

# MARKETING

THE amount of sugar used in the United States in 1915 was 4,257,714 short tons. Of this, 3,389,175 tons were raw cane, the remainder consisting of 861,568 tons of domestic beet and 6,971 tons of foreign refined cane and beet. Of the 3,389,175 tons of raw cane, 150,000 tons were consumed in the raw state, and from the remainder, 3,239,175 tons, about 3,044,825 tons of refined sugar were produced. The per capita consumption was 83.83 pounds, and was made up of:

| | SHORT TONS | PER CENT |
|---|---|---|
| Refined made from raw cane | 3,044,825 | 74.94 |
| Domestic and foreign beet | 862,694 | 21.23 |
| Foreign refined cane | 5,845 | .14 |
| Consumed in the raw state | 150,000 | 3.69 |
| | 4,063,364 | 100.00 |

Among articles of food that contain a large percentage of sugar are jams, jellies, chocolate, canned fruits, condensed milk, confectionery, chewing gum and cordials. It is estimated by Willett & Gray that in 1915 the direct per capita consumption was 31.43 pounds, and that the remaining 52.40 pounds were used in various prepared or manufactured foodstuffs. Over ninety-nine per cent of all the cane sugar consumed in the United States is refined in New York, Boston, Philadelphia, New Orleans and San Francisco. The beet comes chiefly from California, Colorado, Michigan, Utah and Idaho; the maple from the New England states, Ohio and Canada; and the small amount of full duty-paying foreign cane from Java, Peru, Mexico, Central America and Santo Domingo.

During the past eleven years the consumption in the United States has grown at an average rate of 3.57 per cent per annum. In 1911, on account of the abnormally high prices, the increase was practically nil.

The annual per capita consumption of sugar in some of the other countries of the world is as follows:

| | 1914 |
|---|---|
| Servia | 4.60 lbs. |
| Greece | 8.99 " |
| Bulgaria | 9.94 " |
| Italy | 10.45 " |
| Portugal | 13.60 " |
| Spain | 15.91 " |
| Roumania | 17.12 " |
| Turkey | 20.33 " |
| Russia | 29.26 " |
| Finland | 32.54 " |
| Austria-Hungary | 37.38 " |
| France | 39.01 " |
| Belgium | 42.79 " |
| Holland | 53.44 " |
| Norway | 60.37 " |
| Sweden | 60.48 " |
| Switzerland | 74.87 " |
| Germany | 74.95 " |
| England | 89.69 " |
| Denmark | 93.48 " |

The sale and distribution of large quantities of refined sugar is a serious problem and just as important as the production and the refining of the raw product. Competition is so keen, and the questions involved so complex, that the sale of the product really results in commercial warfare.

To dispose of the output of a large plant successfully re-

quires great intelligence, a broad grasp of business principles, strict honor and integrity, and prompt, decisive action in times of fluctuating markets.

Sales managers of the sugar-refining companies of the United States command high salaries, for the success of the business depends to no small extent upon their ability and judgment. Their knowledge of human nature must be broad and sound and it is tested to the utmost in their selection of assistants and brokers, for representatives always reflect the ideals, principles and methods of the parent authority.

The selling of sugar by the refiner direct to the consumer has not been found practicable, as an organization complete enough to keep in touch with consumers in every city, town and village of the country would be so top-heavy and costly to maintain that the price of the commodity to the consumer would be needlessly increased.

As matters stand, people living in the frozen valleys of Alaska, in the scarcely accessible regions of the Rocky mountains and in the lumber and mining settlements of the West, many miles from railroads, can obtain their supply of sugar with almost the same facility as the residents of New York or San Francisco. A system of distribution that makes this possible leaves little to be desired, and a word or two concerning it will be timely at this point.

Sugar is sold by the refiner to the wholesale grocer through the medium of the refinery's broker. From the wholesaler it goes to the retailer, who in turn delivers it to the consumer.

Brokers are important factors in distribution. In every large city and consuming center, each refinery is represented by its own brokers, who keep in constant touch with all the wholesale grocers and manufacturers of their district.

A thorough knowledge of men and methods, sound business principles, diplomatic talents of no mean order and the capac-

ity to act rapidly, but coolly, in business crises are found combined in the successful broker. He occupies a position between the seller and buyer, and it is just as much his prime duty to see that in all transactions full justice is accorded to both as it is to sell the sugar.

Every refinery having its own broker in each consuming center, it follows that the competition for business among the brokers is very keen. When a broker obtains an order from a jobber or manufacturer, he telegraphs it to his principal. The order is usually confirmed and the goods shipped promptly. For his services the broker receives three cents for every one hundred pounds of sugar sold. This compensates him for the services of his salesmen and himself, his office expenses and cost of telegrams, which is heavy.

Manufacturers of foodstuffs of which sugar is an ingredient, buy their supplies through brokers. They do not resell the sugar as such, but use it only in the manufacture of their own special products.

Wholesale grocery jobbers, of whom there are about twenty-five hundred in the United States, are also very important factors in the distribution of sugar. As a rule, they are located in the large centers of population, and have efficient organizations for the purchase and resale of all kinds of foodstuffs. They deal in as many as three thousand different commodities, and their expense of doing business is apportioned over all of these items, thus reducing to a minimum the expense of handling any one of them. Generally speaking, they have large establishments where stocks of all kinds of goods are carried ready for immediate distribution. The aggregate capital tied up in these stocks throughout the country is enormous, but necessary, as the jobber must at all times be ready to deliver to the retailer whatever is wanted in any of his lines. Wholesale jobbers occupy a unique position in the scheme of things. They

are to the commerce of the country what the bankers are to its finances. In other words, they are the bankers of commodities. Their operating staff consists, first, of the buyers, and, second, of the salesmen.

The buyers are men possessing special knowledge concerning the various articles handled by the house. For instance, in the grocery line one will buy nothing but teas and coffees, another canned goods, another sugar, and so on. These men as a rule have devoted years of study to the particular commodity which they are delegated to buy. They are shrewd, keenly alert and always ready to take advantage of market fluctuations in their favor. The margin of profit between the buying and selling price of any commodity is usually so small that the acumen of the buyer is an important factor in the final results.

The salesmen are trained, tactful, tireless and efficient. They travel from town to town and place to place, visiting every nook and corner where human beings congregate, in order to sell the goods carried by the firm. While his calling is a most useful one, the life of a "knight of the grip" is not always pleasant, as he meets with many deprivations and discomforts.

To compensate him for capital invested, for the expense of doing business and for the losses he incurs in bad debts and declining markets, the jobber probably obtains a gross return of fifteen cents on each one hundred pounds of sugar he sells.

The next important link in the chain is the retailer. It is roughly estimated that there are three hundred thousand retail grocers in the United States, many of whom handle and distribute almost as many articles as the jobber. Their lot on the whole is not cast in pleasant places, because of the severe competition they meet in selling their goods.

Competition is a word regarded almost with affection by the buyer, but for the seller of goods it is probably the most unpleasant one in the English language. There is an old axiom

which reads: "Competition is the life of trade." It may be so, but the expression was no doubt coined by a buyer.

Among sellers, competition is in direct proportion to the number engaged in any particular business. It therefore follows that as there are three hundred thousand retailers in the United States, and hundreds in each of all the large cities, the struggle to keep on their feet and continue their various enterprises must be severe. The number of failures occurring every year amply substantiates this assertion. Reckless and unscrupulous men engage in every business, and the competition thus forced on all others in their line is not only unfair, but positively dishonest. Any individual can break a price or introduce new and expensive experiments in selling terms, which must be followed with equally attractive terms by the other sellers, thus resulting in great loss to all. It is no satisfaction that such men finally fail and go out of business, for the losses sustained in the interim can never be recovered.

Another grave difficulty with which the retailer has to contend is the fact that the average individual to whom he delivers his wares is apt to be rather callous when pay-day comes around. It is sad, but true, that those best able to pay are sometimes the most unsatisfactory customers of the retail grocer.

A retailer's expense of doing business is proportionately much greater than that of the wholesaler, and his losses, due to bad or uncollectible accounts, are much heavier. The cost of delivering goods to the consumer's door is high, and a fact that should be remembered, but which is frequently overlooked, is that it costs the grocer just as much to deliver a five-pound package of sugar as a wagon-load. Householders are proverbially careless, and telephone calls for late and urgent deliveries are a source of great annoyance and expense.

To create a pleasing impression, the grocer must keep a clean, sanitary store, and the expense incident to attractive

window and shelf displays to invite attention is an important item. Department and other stores in his town or neighborhood often advertise "leaders" to attract the buying public, in the hope of selling with these leaders other goods at a profit, or because they are overstocked with a particular commodity. Every retailer must, as a rule, meet this unfair competition or lose his trade.

Sugar more than any other staple article is used as a leader, and, as a result, the retail grocer's profit on it is very small. What remains to him out of the selling price of one hundred pounds of sugar does not exceed thirty-five cents, and more than likely it has cost him twenty-five cents to sell it. It is the retail grocer's employé who delivers sugar in the quantity desired to the housewife at her door, and through her hands the pure, glistening crystals reach the family table.

# BEET SUGAR

## SHORT REVIEW OF THE HISTORY OF BEET SUGAR

THE extraction of sugar from beets dates back to 1747, when Andreas Marggraf, professor of physics in the Academy of Science of Berlin, discovered the existence of a sugar in beets similar in its properties to that obtained from cane.

The discovery was little utilized at first, however, and the manufacture of sugar from beets did not attain commercial importance for over half a century, when Franz Karl Achard, a pupil of Marggraf, made discoveries which led to the construction of the first beet-sugar factory in the world, in Silesia, in the year 1799.

The work of Achard soon attracted the attention of Napoleon Bonaparte, who appointed a commission of scientists to go to Silesia to investigate Achard's factory. Upon their return, two small factories were constructed near Paris. Although these two factories were not altogether a success, the results attained greatly interested Napoleon, and in 1811 he issued a decree appropriating one million francs ($200,000) for the establishment of sugar schools, and compelling the farmers to plant a large acreage to sugar beets the following year. He also prohibited the further importation of sugar from the Indies after January 1, 1813.

As a result of these and other drastic decrees, three hundred and thirty-four factories were erected in France during the years 1812 and 1813, and their production was seven million seven hundred thousand pounds of sugar, or an average of eleven and one-half tons to the factory.

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SUGAR BEET

ANOTHER TYPE OF SUGAR BEET

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With the fall of Napoleon Bonaparte, disaster came upon this, one of his greatest achievements, and but one factory survived. The industry was destined to flourish again, however, under the reign of Louis Philippe. In 1836-37 there were five hundred and forty-two factories in France, producing thirty-five thousand tons of sugar, as compared with fourteen hundred and eight tons in Germany, which country had only recently begun the culture of beets.

When Napoleon III became emperor, he so stimulated the industry that in 1853 the French output had doubled. Meanwhile the Germans were making rapid strides, and in 1880 the German output of sugar exceeded that of France. As a result of legislative encouragement, Germany today is the largest beet-sugar producer in the world.

The first successful beet-sugar factory in the United States was constructed by E. H. Dyer, at Alvarado, California, in 1879. The next successful factory was erected at Watsonville, California, in 1888, by Claus Spreckels. The Oxnard brothers followed with the construction in 1890 of a factory at Grand Island, Nebraska, one at Norfolk, Nebraska, and a third at Chino, California, the last built in 1891.

From this it will be seen that the commercial production of beet sugar in the United States really dates back to about 1890, since only three factories of small capacity had been established prior to that date. The development of the industry since the year 1892 has been rapid, and the general results of the beet industry in the United States in 1915 showed the following:

| | | |
|---|---|---|
| Factories in operation | 67 | |
| Acres of beets harvested | 611,301 | |
| Average yield of beets per acre | 10.10 | short tons |
| Beets worked | 6,150,293 | " " |
| Sugar manufactured | 874,220 | " " |

The season of 1916 promises a notable increase in tonnage.

## THE SUGAR BEET

The botanical name of the sugar beet is *Beta vulgaris.* It grows exclusively in the temperate zone, and with satisfactory soil and climatic conditions a yield of thirty tons per acre has resulted. The average yield in the United States, however, is slightly over ten tons per acre. There are many varieties of beets, some of which do better in one locality than another, so that great care must be used in the selection of the seed.

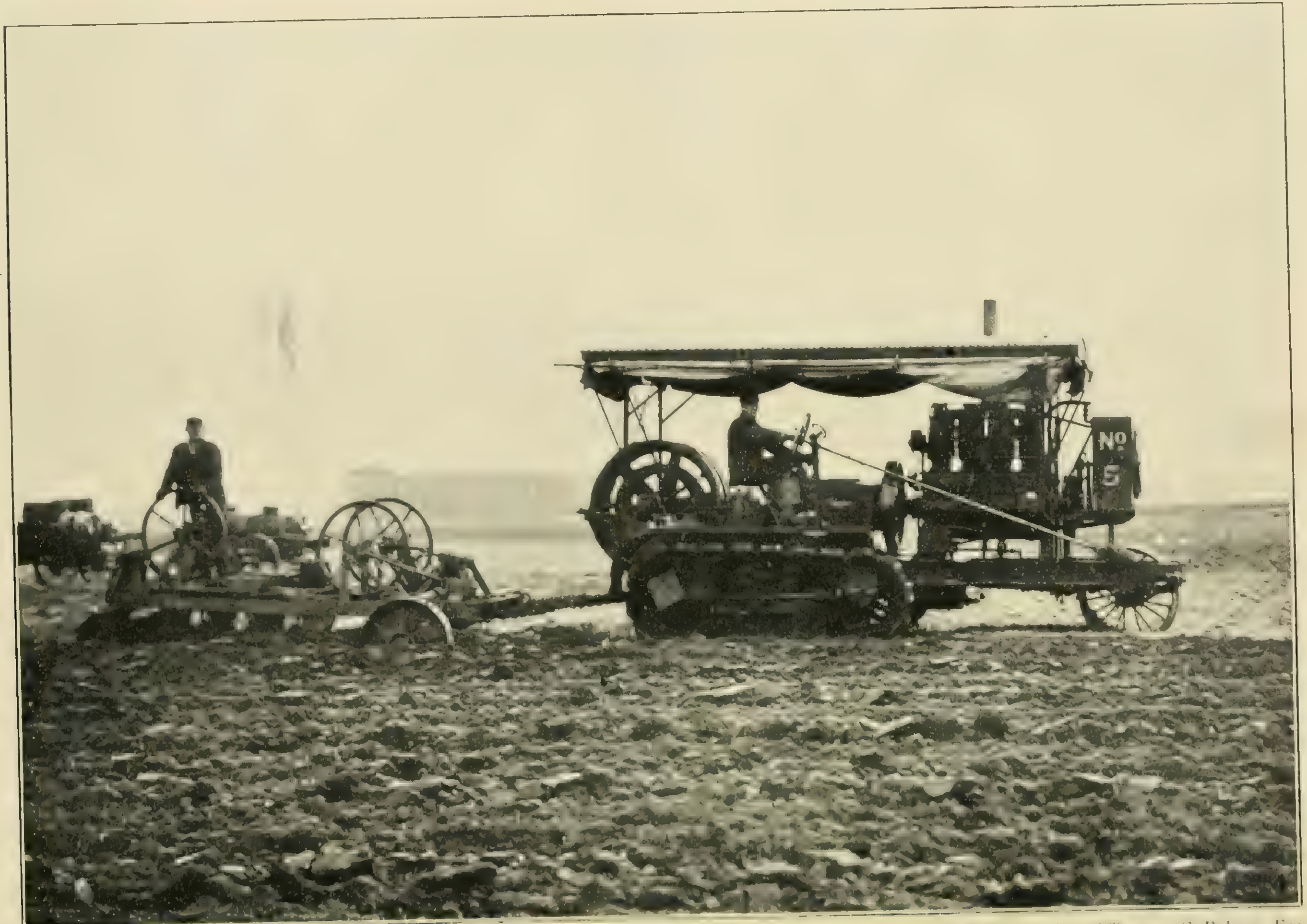
The beet, unlike sugar cane, grows below the ground, is white in color and shaped like the ordinary carrot, but larger. The beets vary greatly in size, depending upon variety, soil and climatic conditions, the average weight ranging between one and two pounds.

The foliage has a rich, brilliant green color and grows to a height of about fourteen inches. The leaves are numerous and broad and grow in a tuft from the center or crown of the beet, which is usually level with or just above the ground surface.

The average composition of a sugar beet is about as follows:

| | |
|---|---|
| Sugar | 17.3 per cent |
| Marc or pulp | 4.4 " " |
| Ash and organic non-sugar | .7 " " |
| Water | 77.6 " " |

The value of the beet to a factory depends on the amount and purity of the sugar content. Factories as a rule decline to purchase beets containing less than twelve per cent of sucrose, as it is unprofitable to handle them. In order to induce the farmer to devote particular care and attention to the culture of his fields and thus increase the sugar content, the factories pay a premium for beets containing over fifteen per cent of sugar. The premium is usually twenty-five cents per ton of beets for each additional one per cent of sugar. Encouraged by this bo-




*By permission of Truman G. Palmer, Esq.*

PLOUGHING WITH CATERPILLAR ENGINE

*By permission of Truman G. Palmer, Esq.*

PLANTING BEET SEED

nus, the California grower has improved the quality of his beets, until today they contain on an average about eighteen per cent of sugar of a purity from eighty to eighty-four.

### SELECTION OF THE SOIL

The sugar beet, like sugar cane, needs a peculiar soil and climate for its successful cultivation. The most important requirement is that the soil shall contain a large supply of plant food, be rich in humus and have the property of retaining a great deal of moisture. A certain amount of alkali is not necessarily detrimental, as sugar beets are not especially susceptible to injury from this salt. The ground should be fairly level and well drained, especially where irrigation is practiced.

While the physical character is of secondary importance, as generous crops are grown in sandy soil as well as in heavy loams, still the ideal soil is a sandy loam, *i. e.,* a mixture of organic matter, clay and sand. A subsoil of gravel, or the presence of hard-pan, is not desirable, as cultivation to a depth of from twelve to fifteen inches is necessary to produce the best results.

Climatic conditions, temperature, sunshine, rainfall and winds have an important bearing upon the success of beet culture. A temperature ranging from 60 degrees to 70 degrees Fahrenheit during the growing months is most favorable. Sixteen inches of rainfall are necessary to raise an average crop of beets without irrigation. High winds are very harmful, as they generally crust the land and prevent the young beets from coming through the ground. The best results are obtained along the coast of southern California, where warm, sunny days succeeded by cool, foggy nights seem to meet every requirement. Sunshine of long duration but not of great intensity is the most important factor in the successful cultivation of sugar beets. The nearer the equator is approached, the poorer

the beets become in sucrose because of the shorter days and the greater heat of the sun. Beets have never been raised with success in the hot interior valleys, as the hot days followed by warm, dry nights sap the vitality of the plant. In the elevated Rocky mountain region of Colorado and Utah, where the temperature is high during the daytime but where the nights are cool, the quality of the beet is excellent.

In Michigan the long summer days and the influence of the great lakes result in satisfactory climatic conditions for sugar-beet culture, and the crops raised in that state are large.

In order to cultivate beets successfully the land must be properly prepared. Deep ploughing is the first principle of beet culture. It allows the roots to penetrate the subsoil without much obstruction, thereby preventing the beet from growing out of the ground, besides enabling it to extract considerable nourishment and moisture from the lower soil. If the latter is too hard, the roots will not penetrate it readily and, as a result, the plant will be pushed up and out of the earth during the process of growth. A hard subsoil is impervious to water and prevents proper drainage. It should not be too loose, however, as this allows the water to pass through more freely than is desirable.

The character of the surface soil is equally important. Careful preparation by harrowing should be done to afford a finely pulverized and clean bed for the seed.

To sum up, the soil should be deep, fairly fine and easily penetrable by the roots. It should also be capable of retaining moisture and at the same time admit of a free circulation of air and good drainage.

## PLANTING

The preliminary preparation of the ground finished, the seed should be put in as soon as the soil is firm enough to allow it to germinate readily and the young plants to grow normally. The

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THINNING

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CULTIVATING

time of planting varies according to climatic conditions. In California planting begins as a rule in December and ends in March, while in Utah, Colorado and Michigan it ranges from March until May.

About twenty pounds of seed to the acre are required to produce a satisfactory stand. The seed is planted in rows, about eighteen inches apart, and is drilled in solidly to a depth of from three-quarters to one and a half inches. The latter is the maximum, as any greater depth than this weakens the plant and should, therefore, be avoided. The soil around the seed is well packed by the planter in order to draw the moisture necessary for germination.

The production of beet seed presents many problems; the chief one is to obtain the particular kind of seed that will bring forth a hardy beet containing a large percentage of sugar of a high purity. The beets from which the seed is produced are selected with the greatest care, and for nearly a century the Luther Burbanks of Europe have devoted their time and skill to improving the quality. Until recently, practically all of the beet seed used in the United States was imported from Europe. Since the outbreak of the great war in 1914, however, the difficulties attendant upon securing a supply have caused the beet growers to turn their attention to raising seed in this country. Their efforts have been rewarded with a fair measure of success, and while the cost is greater than that of European seed, the germinating properties have proven to be excellent. The best results have been obtained in Idaho. Owing to the fact that the culture of the beets and the picking and sorting of the seed are done chiefly by hand, labor enters largely into the cost of production, and consequently, under normal conditions, the growers in the densely populated countries of Europe have a great advantage over those in the United States, where the main difficulty is securing labor for the field work.

Like sugar cane, beets are subject to plant diseases of various kinds, as well as to injury by insect pests, and great care has to be exercised to ward off these dangers.

Probably no other crop exhausts the soil so rapidly as beets, and, if they are planted for many years in succession, they deteriorate year by year. On the other hand, if crops are rotated so that beets are grown in the same ground every third year, peas, beans or grain being raised the other two years, it is a remarkable fact that all of these crops will improve each year. This is due to the intensive cultivation of the beets and to the humus left in the ground in the form of rootlets. Experience has taught the farmer that no other crop is so beneficial to the soil as beets grown in the right rotation and with proper care.

### THINNING

As soon as the beets are up and the rows clearly defined, thinning becomes necessary. This is one of the most important features of beet culture and is a tedious and expensive operation. It consists of cutting out the plants so that individual roots remain, spaced about eight inches apart. The work is done by hand, a hoe being used to block out the spaces, and the roots surrounding the one which it is desired to retain are pulled up. Due partly to faulty germination, but principally to defective thinning of the beets, in which operation a great many of the small, tender beet plants are injured or killed, very much less than the theoretical number of mature beets are secured per acre. With rows eighteen inches apart and a plant every eight inches in the row, 43,000 beets per acre should be obtained, which, at an average weight of one and one-half pounds per beet, would mean 32.25 tons. Owing, however, to the facts just mentioned and to other causes, the actual yield is always much less. The average in California for a number of years past has been only 10.68 tons per acre.

FIELD OF RIPE BEETS

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TOPPING BEETS

### CULTIVATION

The purpose of cultivation is two-fold; first, to retain the moisture in the soil, and, second, to destroy the weeds and grass, as in the early stages of the growth of the beets weeds might spoil the stand by choking the plants.

Cultivation should be continued until the plants have attained such a size that the leaves cover the ground. It increases the fertility of the soil by opening the land to the atmosphere, thus facilitating the penetration of oxygen and absorption of air moisture and the resulting decomposition and assimilation of nutritious elements.

### HARVESTING AND TOPPING

The time when harvesting takes place depends on the many factors that influence the growth and maturing of the beet. In the colder countries the harvesting lasts from September until the ground becomes frozen, while in warmer climates like that of California, where the seed is planted early, harvesting begins about July first and lasts for a period of from seventy-five to ninety days.

The beets are first loosened by means of a specially shaped plough, called the "puller," which lifts them from the ground. They are then picked up by hand and the crown of each beet, together with the leaves, is cut off with a large knife. The leaves contain no sugar, and are, therefore, not taken into the factory, but are utilized for stock feeding, being quite valuable for this purpose. The sugar contained in the crown is accompanied by so many organic salts that it does not pay to extract it.

The topped beets are then loaded into wagons or railroad cars and transported to the factory, at which point they are carefully weighed. In this country most of the beets are raised by farmers and sold under contract to the factories, at so much per ton, so that the determination of the exact weight and

sucrose content is important. For the season of 1915 the average price paid to the farmers for beets was $5.67 per ton.

On arrival at the factory a certain number of beets are taken from every wagon- or car-load, and these represent a fair average of all the beets of that particular delivery. They are sent to the laboratory and their exact weight ascertained, after which they are trimmed of all adhering roots, leaves and parts of the crown, if not properly topped in the field. Any remaining soil is carefully brushed off and the beets thoroughly cleaned. They are then reweighed and the difference between this and the first weight is the tare. This difference represents a certain percentage of the total of the sample beets weighed, and that small percentage is deducted from the gross weight of the total load. In this way the exact net weight of beets delivered by the farmer is determined and he is paid according to this net weight.

The sugar content of the beet and the purity of the juice must now be ascertained, for the price paid the farmer varies according to the amount of sugar the beet contains. As in the case of weighing, sampling and polarizing raw cane sugar, representatives of both parties—the farmer and the factory—are present when all weights are taken and tests made. There are several different methods for determining the percentage of sugar in the beet and the purity of the juice, but the following gives a fair idea of the general practice.

The sample beets having been cleaned, are cut into quarters, one-quarter of each beet being taken for the general sample. This general sample is placed in a grinding or shredding machine, the beets are disintegrated to a fine pulp and thoroughly mixed. A specific amount of this fine pulp is then accurately weighed and placed in a copper pan or dish called a capsule. A small quantity of dilute lead solution is introduced to assist in clarifying, and sufficient water added to bring the volume up

HAULING BEETS

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DELIVERING BEETS TO THE FACTORY BY WAGON

to 200 cubic centimeters. It is then heated for about twenty minutes and vigorously agitated, so that the sugar-bearing juice of the beet will mix evenly with the water that was added. The mixture, after being allowed to stand for several minutes, is filtered through paper and a certain amount placed in the observation tube of a polariscope. The instrument will show the amount of sugar in the solution, and by multiplying the reading by two the per cent of sugar in the beets will be found. If in preparing the sample only sufficient water had been added to bring it to a volume of 100 cubic centimeters, the polariscope would give a direct reading of the percentage of sugar in the beets. Practice has demonstrated, however, that the method described is the more accurate.

To ascertain the purity of the juice, the procedure is as follows: A part of the shredded sample is taken and the juice is squeezed out of it. The amount of sugar in this juice is determined by aid of the polariscope, and a Brix spindle shows the amount of solids it contains. By dividing the polarization by the Brix and multiplying by 100 the purity is obtained, which means the percentage of pure sugar in the total amount of solids contained in the solution.

The purity of the juice has an important bearing on the subsequent manufacture of the sugar. It is difficult and costly to extract sugar from low-purity juices, and the loss of sugar in the process is very high. The reverse is naturally true if the juices have a high purity. The purity of the juice in the beet is materially affected during the growing period by climatic conditions, rainfall, irrigation, fertilization, state of soil and cultivation. Great care and attention must be given the beet to insure high purity and heavy content of sugar.

From the above it will be seen how the net weight and the percentage of sugar in any particular wagon- or car-load of beets are ascertained, as well as the purity of all the beets that

enter a factory. The efficiency of the work in a factory is based on the figures thus obtained.

## MANUFACTURE OF BEET SUGAR

The process of making sugar from the beet is highly technical in its details and cannot be fully discussed within the scope of this work. A brief description, however, will give an idea of the general methods followed.

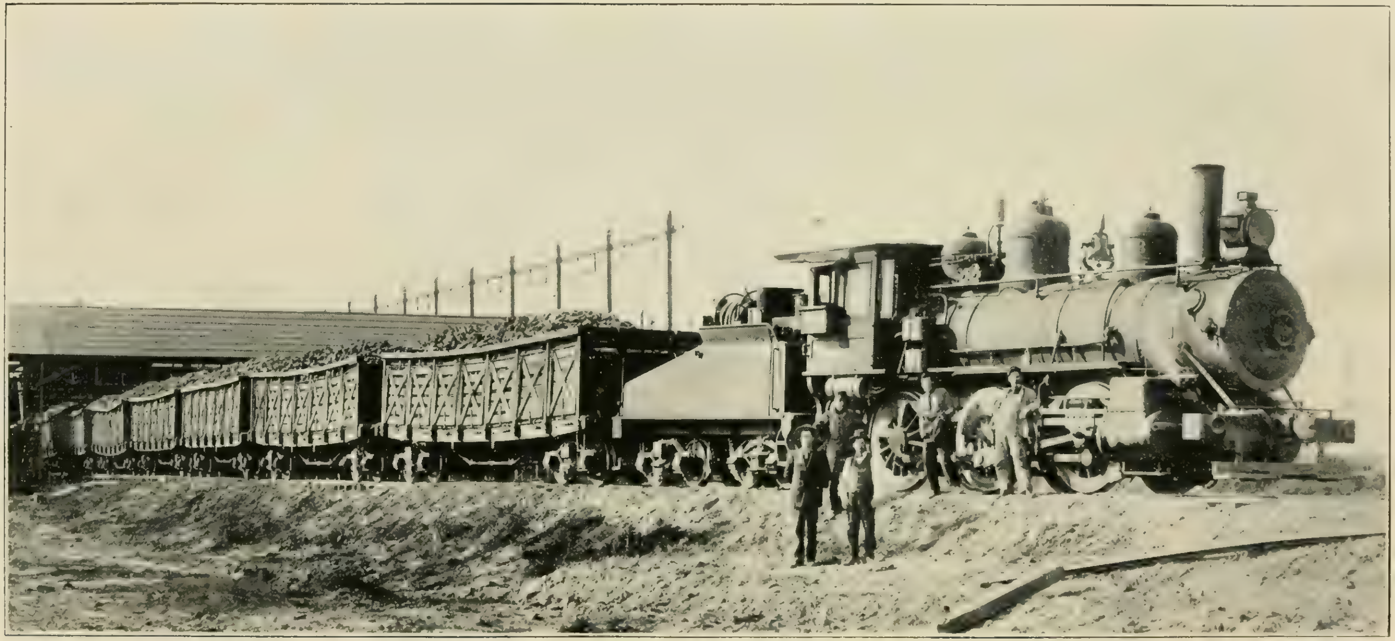
The process of manufacture may be classified under seven headings:

1. Transportation and cleaning of beets.
2. Extraction of juice, slicing and diffusion.
3. Purification, carbonation, filtration, concentration and sulfitation.
4. Formation of grain.
5. Partial drying, purging crystals from syrup in centrifugals.
6. Final drying.
7. Packing.

## TRANSPORTATION AND CLEANING

The beets, after delivery to the factory, are stored in V-shaped bins, in the bottom of which is a flume covered by removable boards. By removing the boards, one at a time, the beets are fed into the flume, where a swift current of water floats them into the factory. From this flume the beets are lifted by means of a large wheel, a helical screw or any other suitable device, and discharged into a washer.

The common form of washer consists of a horizontal, semicylindrical tank provided with rotating, kicking or stirring arms for keeping the beets in motion. In this tank the beet is completely cleaned and separated from adhering earth, weeds and pebbles.



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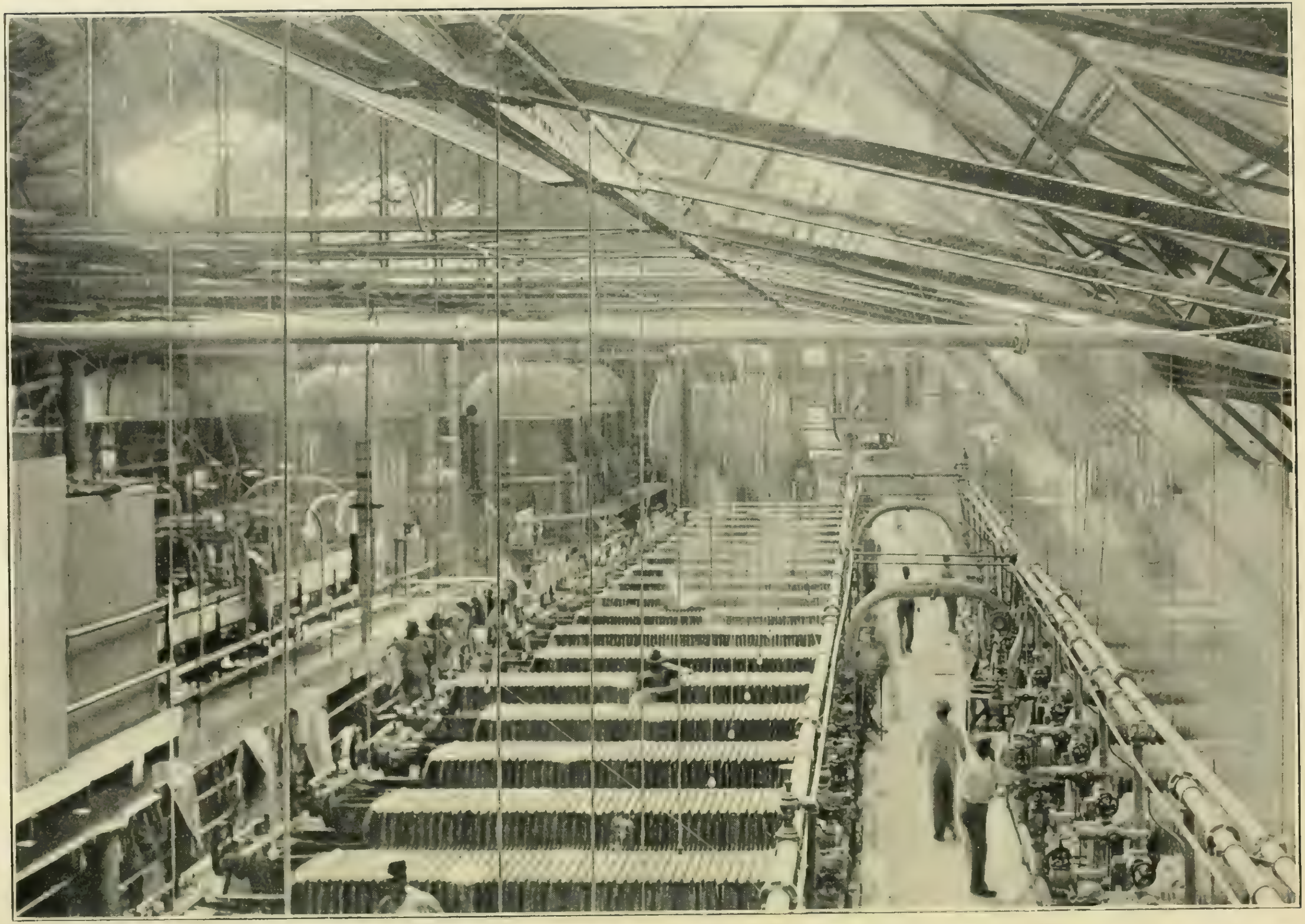
DELIVERING BEETS TO THE FACTORY BY TRAIN



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GENERAL INTERIOR VIEW OF BEET-SUGAR FACTORY—SHOWING FILTER PRESSES IN FOREGROUND; PANS AND EVAPORATORS IN REAR

The beets are delivered from the washer into an elevator, which takes them to a point near the top of the factory and discharges them into automatic weighing and recording scales. From the scales the beets fall by gravity into the slicing machines.

### EXTRACTION OF JUICE, SLICING AND DIFFUSION

The slices are made in various shapes and forms. The slicing machines consist of revolving, corrugated knives which cut the beets into long, thin slices or "cossettes." The object is to produce slices which expose the greatest amount of surface, and yet sufficiently firm to lie not too closely together when placed in the diffusion battery, thereby preventing the circulation of the diffusion liquors. The cossettes are conveyed on an endless belt, or through a hopper, to the cells of the diffusion battery.

As the term implies, the juice in the beet is extracted by diffusion, and not by crushing, as in the case of cane. When two liquids, separated by a membrane, are brought in direct contact with each other and allowed to stand for a time, they mix uniformly without the assistance of mechanical or other force.

Beets are made up of a great number of plant cells, the walls of which are porous membranes. These cells are placed in contact with water or juice of lesser sugar content than the juice in the plant cell, in consequence of which the juice is gradually diffused from the beet and carried away in the circulating water which is added. When this water, or rather juice, has reached a certain stage of concentration, it is drawn out of the cells and sent to the next stage in the process of manufacture.

A diffusion battery, or the apparatus in which the process of diffusion is carried on, consists of a number of tanks or cells, usually from ten to fourteen, cylindrical in shape and terminating in truncated cones provided with covers. There are two ways of arranging the cells of a diffusion battery; in the one

case the cells are placed in a straight line; in the other they are grouped in a circle. These cells are filled with cossettes in rotation, and water is introduced into the one in which the cossettes were first placed.

Thus the water enters the tank in which the cossettes are nearly exhausted of their sugar, and it flows successively through the other cells that contain cossettes of greater sugar content until the last cell, or the one containing fresh cossettes, is reached. The juice passing through this cell is alternately sent to the measuring tank or to the next cell, which has just been filled with fresh cossettes. The process is continuous, one cell being emptied of exhausted cossettes while another is being filled with fresh ones, and the juice flowing either to the measuring tank or to the freshly filled cell.

The exhausted cossettes, now called pulp, are dropped from the bottom of the diffusion tanks into a large bin, from which they are conveyed or pumped to pulp separators and presses for the separation of the surplus water. This pressed pulp is usually stored in large bins or silos, where it is allowed to ferment before being fed to cattle.

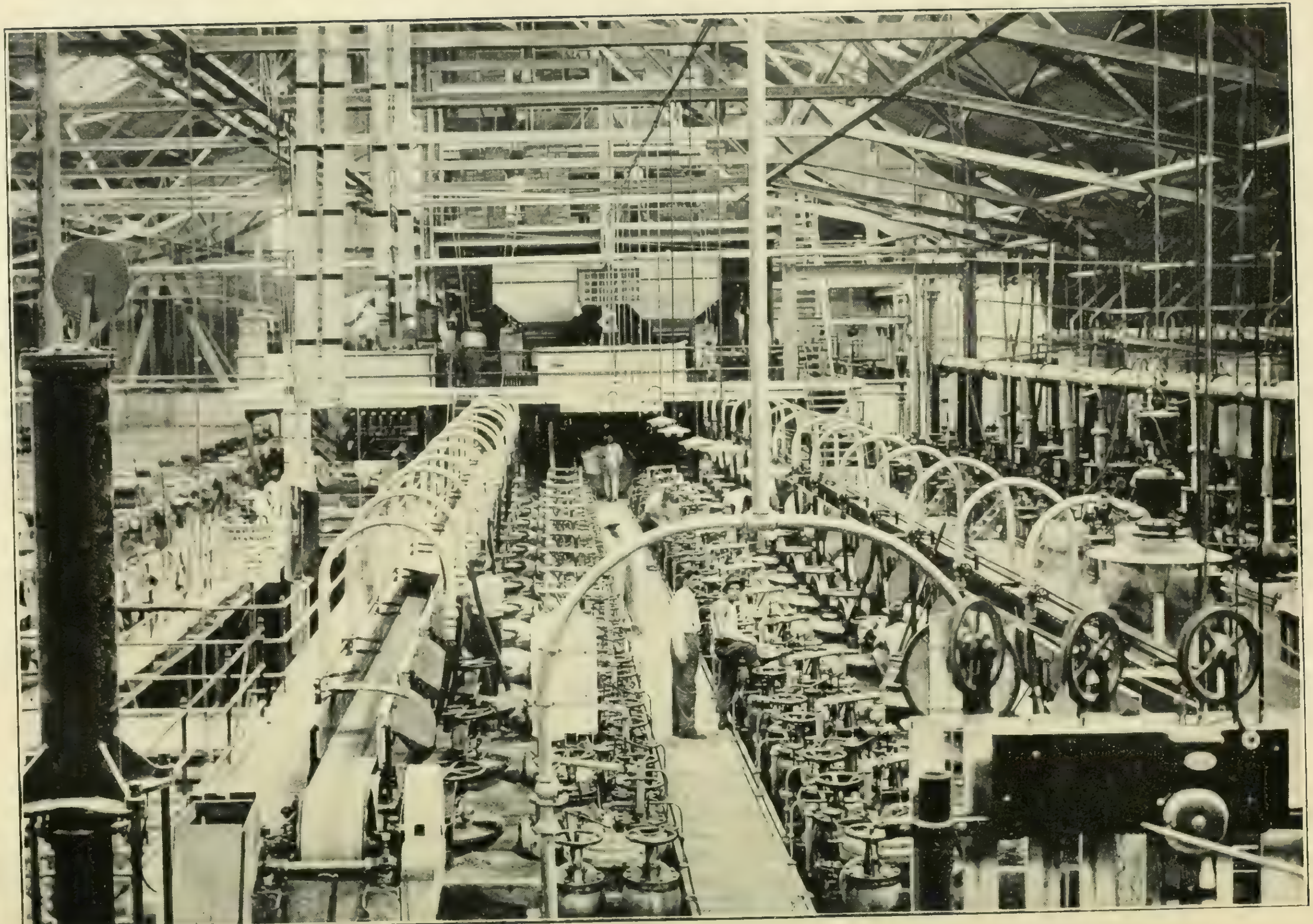
Recently the practice of drying the pulp has been carried on to a large extent. In this process the moisture in the pulp is reduced to ten per cent, the same proportion as in cured hay. Dried to this point, it is packed in bags and may be stored for an indefinite period without deteriorating. After being treated thus it forms an excellent stock food, particularly if waste molasses is sprayed on it before drying.

### PURIFICATION OF JUICE, CARBONATION AND FILTRATION

The diffusion juice obtained as above described is quite dark in color, and after passing through the measuring tanks it is conveyed to carbonation tanks where it is treated with from three to four per cent of caustic lime in the form of a thick milk.

DIFFUSION BATTERY—SHOWING DIFFUSION CELLS IN CIRCULAR ARRANGEMENT

*By permission of Truman G. Palmer, Esq.*



*By permission of Truman G. Palmer, Esq.*

DIFFUSION BATTERY—SHOWING DIFFUSION CELLS IN STRAIGHT LINES

After being thoroughly agitated, the mixture is treated with carbonic acid gas obtained from the lime-kilns, as the result of the decomposition of limestone and the combustion of the fuel used for burning it.

By this process some of the impurities in the juice are removed and the color reduced to a brilliant amber. As is the case in the cane mills and refineries, it is essential to keep the juice hot throughout the process. The carbonation is continued until the juice is only slightly alkaline, when it is passed through filter presses for the removal of the precipitated lime carbonate and other solid matter. The solid matter in suspension is retained in the frame of the press, and, as soon as the frame is full, the cake is washed by passing water through it. When the sugar content of the cake has been sufficiently reduced, the press is opened and the cake discharged and sent to the fields to be used as a fertilizer.

As a rule, the filtration is repeated for the elimination of any solids that may have passed through the first filtration. This double filtration is usually practiced in all the filtrations in the course of the juice through the factory.

The juice after being filtered a second time is again treated with carbonic acid gas for the further reduction of the caustic lime and then undergoes a third filtration, following which it is sent to the evaporators for concentration.

## CONCENTRATION OF JUICE

When the juice reaches the evaporators it contains about eighty-two per cent of water, which, by concentration, must be reduced to about forty per cent. As already explained, the removal of water is generally accomplished in multiple-effects. The apparatus consists of a number of boiling bodies connected in such a manner as to secure a progressive decrease in atmospheric pressure.

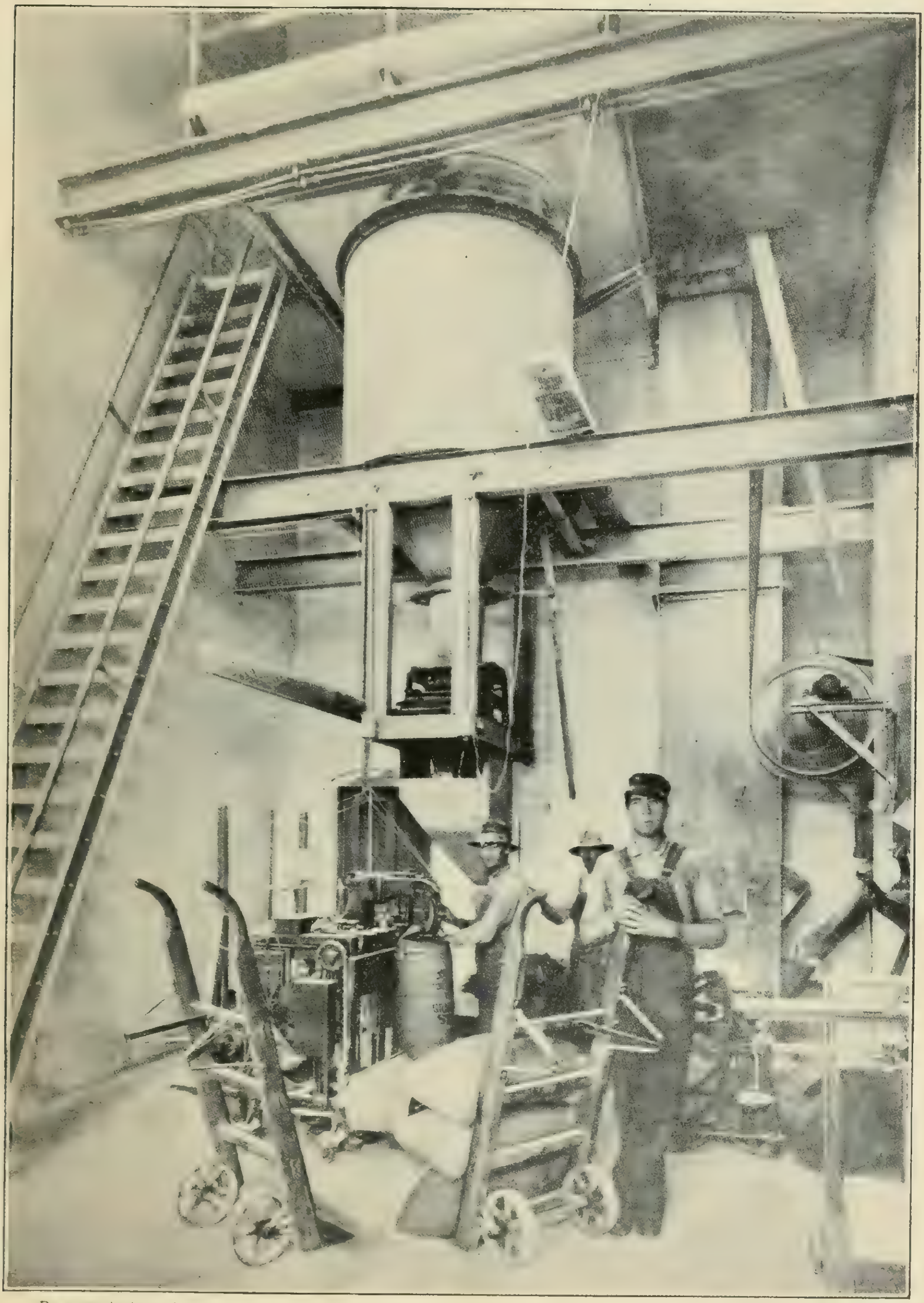
The thin juice enters the first body where evaporation takes place under a slight pressure. The steam for this evaporation is usually the waste or exhaust from the engines and pumps. The vapors generated by the evaporation of water from the juice in the first body enter the heating tubes of the second body and are used in further concentrating the somewhat concentrated juice from the first body. The evaporation in this second body is conducted at a higher vacuum and corresponding lower temperature than in the first body. This proceeding is continued until five or even six bodies are used in the series. The last body is usually under a vacuum of about twenty-six inches of mercury.

It is obvious that by this arrangement the concentration of the thin juice is effected with the maximum of economy, direct steam being admitted into the first body only and the rest of the operation accomplished by the steam generated in the boiling of the juice.

### SULFITATION

The thickened liquor leaving the last body of the evaporators is sent to the sulphur station and treated with sulphur fumes, in order to further precipitate the soluble impurities and reduce the color of the liquor. It is then heated to boiling point in closed tanks and passed through a double set of cloth filters. This is the final process in the purification of the beet juice, and it is then ready for graining.

In a cane-sugar refinery no sulfitation of the liquor takes place, and in a beet factory there is no char filtration for removal of color and impurities in the liquor. These two points constitute the main difference in the methods of making white sugar from the cane and the beet in the United States. In Europe, however, many factories make a raw beet sugar, which is subsequently refined with the aid of bone-char.



*By permission of Truman G. Palmer, Esq.*

WEIGHING, FILLING AND SEWING BAGS IN A BEET FACTORY

*By permission of Truman G. Palmer, Esq.*

CATTLE FEEDING ON BEET PULP

### FORMATION OF GRAIN

The formation of the crystallized grain and its progress through the vacuum pans, centrifugals, driers, granulators and screens, and into the bags in the packing room, is identical with the process in a cane refinery, which has already been described.

### STEFFEN PROCESS

In some of the beet factories the sugar left in the final molasses is extracted by what is known as the Steffen process. The final low-purity molasses is diluted with water and cooled to a very low temperature, after which finely powdered lime is constantly added to the solution at a uniform and slow rate. The sugar combines with the lime and a saccharate of lime is formed which is insoluble in the liquid. The suspended matter or saccharate is then separated and washed in filter presses.

The cake from these filter presses, which is the saccharate of lime, is mixed with sweet water to a consistency of cream and takes the place of milk of lime in the carbonation process. When the Steffen process is employed, about ninety per cent of the sugar originally in the beet is extracted. The loss of sugar that does take place is accounted for in the exhausted cossettes or pulp, in the pulp water which surrounds them when they are dumped from the diffusion cells, in the cake and wash waters from the carbonation presses and in the waste and wash waters from the Steffen process. As the water used in washing the saccharate press cake is rich in fertilizing qualities, it is used for irrigating the lands adjoining the factory.

The 6,511,274 tons of beets harvested in the United States during the season of 1915 contained an average of 16.49 per cent of sucrose, of which 14.21 per cent found its way into the sacks as white sugar. The difference, 2.28 per cent, represented the loss in working up the beets. As only a few factories, however, were using the Steffen process, a considerable

amount of sugar was left in the waste molasses. For the same period, the beets produced in California contained 17.82 per cent of sugar, of which 15.64 per cent found its way into the sacks, showing a loss of only 2.18 per cent. This may be accounted for by the fact that probably more of the California factories were equipped with the Steffen process than the average for the United States, and that the purity of the juices of California beets was higher than the average for the United States.

A factory equipped with the Steffen process and running on beets containing 17.82 per cent sugar, with a purity of 82, should lose not over 1.9 per cent of the sugar in the beet. The same factory without the Steffen process would probably lose 5.04 per cent of the sugar.

It is interesting to know that, according to the testimony given before the Hardwick committee, the average cost of producing and selling one hundred pounds of white beet sugar in the United States today is about three dollars and fifty cents. The selling price, which is from ten to twenty cents per one hundred pounds less than the selling price of refined cane sugar, fluctuates with the value of raw cane sugar. For instance, if raw cane sugar is selling in New York at four dollars per one hundred pounds, the selling price of refined cane will probably be four dollars and eighty cents. Beet sugar, therefore, would be four dollars and seventy cents or four dollars and sixty cents. On the other hand, if raw cane were selling for three dollars per one hundred pounds, refined would probably be three dollars and eighty cents and beet sugar three dollars and seventy or three dollars and sixty cents. In the one case the beet factory makes a large profit; in the other a very small profit.

As the value of raw sugar is determined absolutely by the law of supply and demand in the world's markets, it is clear that the fortune or misfortune of the beet-sugar producer is beyond his control.

THE FIRST SUCCESSFUL BEET-SUGAR FACTORY IN AMERICA—ALVARADO, CALIFORNIA

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*By permission of Truman G. Palmer, Esq.*

A MODERN BEET-SUGAR FACTORY

# Part II

## *History of the Industry*

# EARLY HISTORY

INDIA, the land that Kipling has called "the grim stepmother of mankind," is, according to the best authorities, the original habitat of the sugar cane; and there is but little doubt that the properties of the plant were known to the Hindustani many centuries before the Christian era. Nothing concerning it is found in the Old Testament, the Talmud or in the oldest Hindu literature; and even in Buddha's time (500 B. C.) it was little known.

The legend runs that sugar cane was created by the famous hermit Vishva Mitra to serve as heavenly food in the temporary paradise arranged by him for the sake of Raja Trishanku. It was the desire of this prince to be translated to heaven during his lifetime, but Indra, the ruler of the celestial realms, had refused to admit him. In order to gratify Trishanku's wish, Vishva Mitra prepared a temporary paradise for him. When a reconciliation between Indra and Trishanku was brought about, the paradise was demolished and all its luxuries destroyed save a few, among which was sugar cane. This subsequently spread over the land of mortals as a lasting token of Vishva Mitra's miraculous deeds.

Among the Chinese the first historical mention occurs in writings of the eighth century B. C., where the fact is recorded that their knowledge of sugar cane was derived from India. That it was considered of great value by the Chinese is shown by manuscripts of 200 B. C., wherein it is stated that the kingdom of Funan paid its tribute to China in sugar cane. From this it may be inferred that the secret of extracting crystals from the sugar-cane juice had not been discovered.

More than three centuries before Christ, the triumphant progress of Alexander the Great was halted upon the banks of the river Indus by the refusal of his troops to venture farther eastward. On their return journey, the Macedonian soldiers carried the "honey-bearing reed" to Europe.

A number of classical writers of the first century allude to the sweet sap of the Indian reed and to the granulated, salt-like product imported from India under the name of *saccharum,* or σάκχαρι, from the Sanskrit *çarkarā,* gravel, sugar. The names of sugar in modern European languages are derived through the Arabic from the Persian *shakar.*

The people dwelling in the valleys of the Ganges possessed a knowledge of boiling sugar juice, and this spread from there to China in the first half of the seventh century. Sugar refining, however, could not then have been known, for Marco Polo[1] states that the Chinese learned this from Egyptian travelers only during the Mongol period, some five hundred years later. Von Lippmann says that solid sugar began to be known in India somewhere between 300 and 600 A. D., probably nearer the latter date.[2] In the Middle Ages, the best sugar came from Egypt[3]; and in India today, coarse sugar is still called "Chinese" and fine sugar "Cairene" or "Egyptian."

The Nestorians, a Christian religious sect in Gondisāpūr, India, planted sugar cane in Persia about 500 A.D. When Heraclius,[4] the Byzantine emperor, pillaged the palace of Dastargerd, Persia, in 627 A. D., solid sugar was taken among the other loot.[5] This is the first authentic evidence of crystallization. At the time of the Arabian conquest in the year 639, sugar

1 Ed. Yule, II, 208-212. 2 *Geschichte des Zuckers,* p. 89. 3 Kazwini, I, 262.

4 610-641 A. D. 5 See *Greece under the Romans,* by George Finlay, LL. D., page 338; "The sixth campaign opened with the Roman army in the plains of Assyria, and after laying waste some of the largest provinces of the Persian empire, Heraclius marched through the country to the east of the Tigris and captured the palace of Dastargerd, where the Persian monarchs had accumulated the greater part of their enormous treasure in a position always regarded as secure from any foreign enemy."

was "prepared with art" in Gondisāpūr; and its manufacture on a large scale was carried on at Shuster, Sūs[1] and Askar-Makram[2] through the Middle Ages. Thaálibí, a writer of the eleventh century, says that Askar-Makram had no equal for the quality and quantity of its sugar, "notwithstanding the great production in Irāk, Jarjān and India." It used to pay fifty thousand pounds of sugar to the Sultan in annual tribute.[3] Persian physicians of the time attributed extraordinary healing powers to sugar, and used it freely in the practice of their art.

Mohammed's[4] religious wars carried the knowledge of sugar throughout the cities of the then civilized world. The Arabs first learned of it when they overran Persia. They took to it eagerly, and under their rule a great number of plantations were started. Artificial irrigation was employed in the growing of the cane, and the juice was expressed by means of millstones. At this period, however, sugar was looked upon as a rare and costly luxury, to be indulged in only by the wealthy, and sparingly even by them.

Arabian doctors who were well advanced in learning gave sugar an important place in their pharmacopœia. The Moslem armies took it westward with them; and when Amru[5] conquered Egypt (640-646 A. D.), it was introduced in that country. Careful methods of cultivation, coupled with the Egyptians' intimate knowledge of chemistry, brought about excellent results. This cultured people had a simple process for purifying and recrystallizing saltpeter, and they soon found that sugar could be similarly treated.

The first crystals were remelted; and to the liquor so obtained albumen and lime were added. The precipitated impurities were removed by filtration, and the clear syrup boiled down to a grain once more. The syrup, or mother-liquor in which

[1] In Morocco. [2] Important village of the province of Kūzistān. [3] Latāif, page 107. [4] B. 571-D. 632 A. D. [5] Amr-ibn-el-Ass.

these grains remained after boiling, was eliminated by washing, leaving the white sugar crystals, which in point of quality far surpassed any product then known.

From this time forward, the traffic in sugar began to gain in importance and volume. Nasiri Khosrau, in his account of his travels in Egypt in the eleventh century, narrates that at the celebration of the great Ramazán feast, the Sultan's table was decorated with sweetmeats consisting entirely of marzipan[1] modeled into shapes of orange trees and statues.

The continuation of the movement of the Arabs toward the west carried the cultivation of sugar over the entire northern coast of Africa and thence into Spain in the year of the conquest of Granada by the Moors (715 A. D.). It made its way to Sicily in 703; it was found growing at Assuan, on the Nile, in 766, and the Crusaders discovered important sugar plantations in Tripoli, Mesopotamia, Syria, Palestine, Antioch and other places in the Levant. Commercial relations between these points and the principal Italian cities were established during the Crusades, and a considerable trade in sugar followed.

Sugar-cane cultivation seems to have appealed to the Crusaders as a profitable venture—so much so that they actively interested themselves in it, making Tyre an important center of the traffic. King Baldwin and various orders of knighthood established large cane plantations in Antioch, Syria and Cyprus and did much to advance sugar production in those countries.

The Crusaders who had acquired a taste for sugar when in the Far east naturally wished to continue its use after their return home; thus, a trade sprung up between northern Europe and Venice, Genoa and Pisa.

After the fall of Acre in 1291, the Crusaders lost their foothold in Asia Minor; but Tyre, Beirut, Antioch and the valley of the Jordan continued to produce good crops of sugar, while

[1] *Marchpane,* a sweetmeat made of sweet almonds and pounded sugar.

Damascus and Tripoli became refining centers. Cyprus, still under Venetian rule, extended its trade in sugar, and sent considerable quantities annually to the mother city. All this time the production in Egypt went steadily forward.

This prosperity was rudely interrupted by the aggression of the Turks. Constantinople was captured in 1453 and Trebizond fell in 1461. The other commercial towns of Asia Minor and all of Genoa's Black Sea colonies followed in quick succession. Trade between Europe and Asia Minor decreased as a matter of course and the manufacture of sugar languished under Turkish rule.

In 1517 Cairo was taken by the Turks, and Egypt became a province of the Ottoman empire, with disastrous results to the sugar industry there. In 1522 Rhodes, and in 1571 Cyprus, passed under the sway of the Turk; but by that time sugar cultivation in these islands had fallen off greatly, while in Sicily it had completely died out.

Other causes militated to bring about the decline of the sugar trade in these countries. The Portuguese took sugar cane to Madeira in 1419. In 1432 they captured and colonized the Azores; and between 1456 and 1462 they acquired the Cape Verde islands. São Thomé, Principe and Annobon were annexed in 1496; and in that same year the Spaniards colonized the Canaries. Sugar cane grew luxuriantly in the mild, moist climate of these islands, and the cost of production by slave labor was so low that neither Cyprus nor Sicily could compete; consequently, the once large and prosperous sugar trade of the Mediterranean became a thing of the past.

During the Middle Ages, Venice was the chief sugar-distributing center in Europe. One of the earliest references to sugar in Great Britain is that concerning one hundred thousand pounds shipped to London in 1319 by Tomasso Loredano, a Venetian merchant. Wool, which at that time constituted the

most important staple of English products, was exchanged for sugar. In the same year, an entry appears in the accounts of the Chamberlain of Scotland, showing a payment for sugar at the rate of one shilling and nine pence halfpenny per pound. It is said that at the end of the fifteenth century a citizen of Venice received a reward of 100,000 crowns ($111,940) for having invented the process of making loaf sugar. Vasco da Gama's exploit in finding the way to Calicut by sea in 1498 deprived Venice of her position as a dominant commercial center; and new routes for the world's trade were opened up. The discovery of America exercised a still greater influence upon the production and distribution of sugar.

Christopher Columbus' first attempt to establish sugar growing in Santo Domingo in 1493 [1] was not a success; but when negro slaves were brought to the West Indies by the Portuguese and the Spaniards, the industry took a new lease of life, and with slave labor, ideal climate and fertile soil, it increased abundantly. As illustrative of the extensive development in Santo Domingo, it is interesting to note that Charles V of Spain obtained from import taxes on Santo Domingan sugar the vast sums of money expended in the building of the royal palaces at Madrid and Toledo.[2]

Brazil was discovered by Pinzon in 1499[3] and sugar cane was taken there from Madeira. About thirty-three years later plantations had been laid out and the first sugar factory built. The year 1590 saw one hundred and two mills in operation in the provinces of Bahia and Pernambuco; and in 1600 the quantity of sugar exported from Brazil was 15,000 tons. At that time Brazil belonged to Spain, which had annexed Portugal and her colonies in 1580. It was conquered by the Dutch in 1629, and a

[1] *Encyclopædia Britannica*, Vol. XII, p. 826, gives 1506 as date of introduction of sugar in Santo Domingo. *Encyclopædia Britannica*, Vol. XXVI, p. 44, says sugar carried to Santo Domingo in 1494. [2] *Encyclopædia Britannica*, XXII, p. 658. [3] O. S.

Christopher Columbus

Fra Sebastiano Del Piombo

great many sugar plantations and factories were destroyed; but these were subsequently restored by the new rulers. The Dutch, in turn, were expelled in 1655; and in 1661 Brazil was acknowledged to be a Portuguese possession. The sugar trade suffered, however, on account of the banishment of twenty thousand Dutch in 1655, and also through the discovery of gold in 1725, which drew the laborers from the sugar fields and mills; and the production fell off to a large extent.

The island of St. Christopher (now St. Kitts) was occupied in 1625 by both the English and the French. Ten years later the French took Guadeloupe and Martinique; Barbados became a British possession in 1627, and Jamaica was annexed in 1656. Sugar cane was planted in all these colonies, but through lack of knowledge and experience the product obtained was of indifferent quality. A decided improvement was brought about when the Dutch, who were expelled from Brazil, came to the islands in 1655.

Santo Domingo was taken over permanently by the French in 1697 after it had previously been occupied and abandoned by them. From this date the industry throve there and for upward of one hundred years Santo Domingo ranked among the foremost of the sugar-producing islands of the West Indies. Tyranny and cruel treatment caused the slaves to revolt in 1791; the whites who failed to escape were exterminated and the sugar plantations and mills were destroyed.

Santo Domingo has never recovered the prestige in the sugar world that she lost in this way. Her misfortune gave a great opportunity to Jamaica, whose production increased so rapidly that at the close of the eighteenth century she outstripped all the other West Indian islands. The falling off in Santo Domingo stimulated the industry in Cuba as well. As a dependency of Spain, Cuba was hampered by a number of restrictions; these were repealed in 1772, after which the sugar tonnage grew apace.

St. Eustatius and Curaçao belonging to the Dutch, and St. Croix, St. John and St. Thomas to Denmark, also came in for their share of the benefit growing out of the impetus given to the sugar trade at this time. It must be borne in mind, however, that they were conveniently situated for sugar smuggling, of which there was not a little during the American Revolutionary war.

In the countries of South America, Brazil excepted, the sugar trade had become well established. French planters settled in Cayenne in 1634 and in Surinam six years later, but production was handicapped by the difficulty attendant upon securing labor, and this condition continued to exist even after the taking of Surinam, Essequibo, Demerara and Berbice by the Dutch. Finally the trouble was overcome by bringing in slaves, and with the end of the French war the sugar industry began to prosper, especially in Surinam. During subsequent hostilities these colonies were taken by France, afterwards by England, and later still they reverted to the Dutch. Today they are all British with the exception of Surinam and Cayenne.

Sugar cane was not known in Peru at the time of Pizarro's first expedition to that country (1527), but it was brought there shortly afterward. In Chile and the Argentine its introduction was comparatively recent. The Jesuits took it from Santo Domingo to Louisiana in 1751, and in Mexico it dates back to the time of Cortés.

The rapidity of the increase in the production of the Americas threatened the plantations of Madeira, the Cape Verde islands and the Canaries with extinction and drove them from the world's markets.

Sugar cane was planted by the French in the Ile de France (Mauritius) in 1747, and some years later in Bourbon (Réunion) and sugar made in these islands was sent to Europe about the end of the eighteenth century.

In Java sugar cane has been grown since a very remote period. It was probably brought there by Chinese traders and there is evidence that the Chinese introduced it in the Philippine islands, as the names of the implements and methods used there distinctly point to Chinese origin.

The cultivation of sugar cane in Australia was begun only fifty years ago; it was started in the Fiji islands in 1880, while Captain Cook found cane growing luxuriantly in the Hawaiian islands when he discovered them in 1778.

The wars between Great Britain and France during the latter part of the eighteenth century and the beginning of the nineteenth had a very bad effect on the cane-sugar trade and its development. There was constant fighting in West Indian waters and many merchant vessels were taken as prizes; a disastrous state of affairs for planters and merchants alike. After the battle of Trafalgar had definitely established British supremacy on the seas, Napoleon put into effect his "Continental System," which dealt a severe blow to cane sugar. This opens up a new and interesting chapter in the history of the industry.

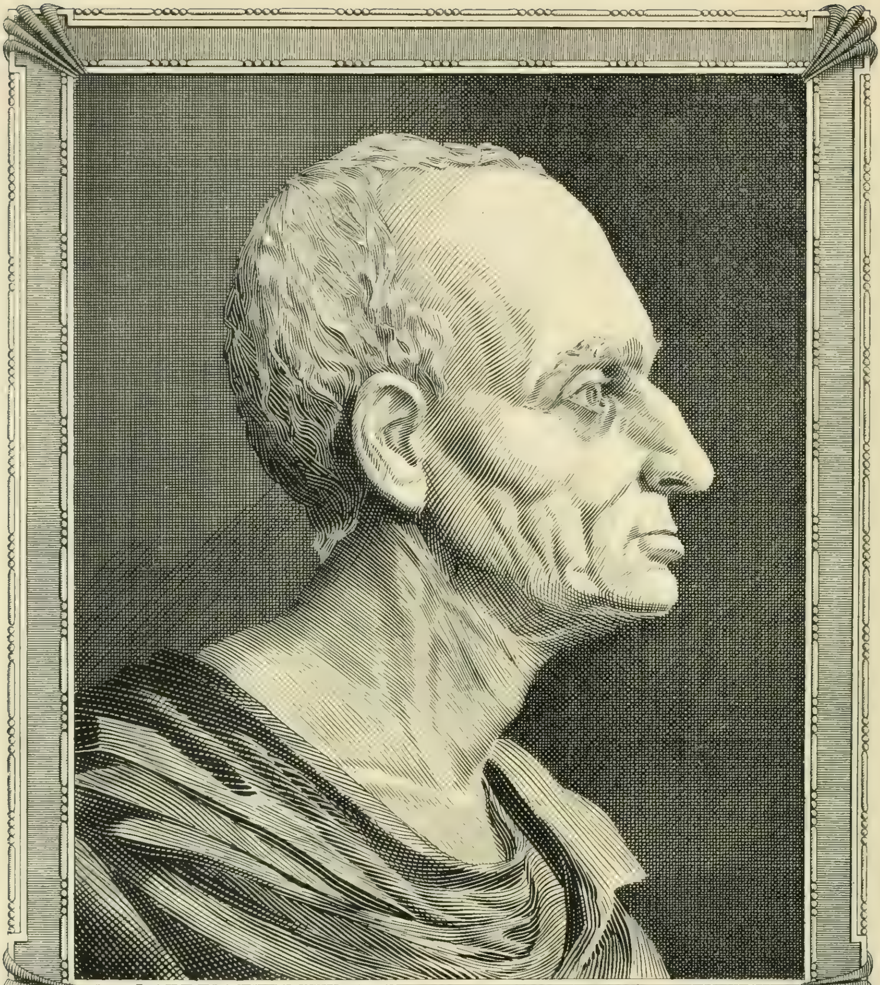
# BEET SUGAR IN EUROPE

THE destruction of the French fleet by Nelson in 1805 thwarted Napoleon's long-cherished plans for the invasion of England. Nothing daunted, however, he immediately bent his efforts toward isolating Great Britain and cutting commercial communications between her and the continent of Europe. The Berlin edict of 1806 prohibited all trade relations with England and made her goods and those of her colonies subject to seizure. England's reply was to forbid ships of all nationalities to enter French ports under penalty of confiscation. Napoleon followed this with the Milan decree which made any vessel that had submitted to English examination or paid dues in English ports subject to confiscation. The one government vied with the other in preying on commerce. The interference with the importation of sugar due to this condition drove prices upward to a point where only a few could afford its use.

Napoleon was fully cognizant of what a privation this was to his people, but he felt confident that means would be found to bring sugar from the Far east to western Europe by way of Constantinople and Vienna; besides, he had strong hopes that a substitute for cane sugar could be produced in Europe itself. He encouraged experimental and research work, keeping thoroughly informed as to progress made, and on March 25, 1811, he issued the famous decree that set in motion the beet industry of the world.

The original home of the sugar beet *(Beta vulgaris)* is not definitely known. The plant was found in a wild state in southern and middle Asia and it is said to have been cultivated in

Olivier de Serres



*Andreas Marggraf*

southern Europe and northern Africa in olden times. According to Professor Griffin,[1] Herodotus mentions the sugar beet as one of the plants that served to nourish the builders of the pyramids. Dr. von Lippmann cites the same instance and also quotes Voltz as authority for the statement that the Romans first brought the beet into Gaul.

When the beet was originally grown in southern latitudes it was an annual, but when it was taken north it became a biennial, storing sugar the first year and not developing its seed until the second.

Jules Hélot, an eminent French authority, in his "Histoire Centennale du Sucre de Betterave," says:

"A great French agronomist, called the father of agriculture, Olivier de Serres (1539-1619), was able to find out that the beet-root contained sugar, long before Marggraf set about to extract sugar from this root. Olivier de Serres wrote: 'The beet-root, when being boiled, yields a juice similar to syrup of sugar, which is beautiful to look at on account of its vermilion color'."

Dr. von Lippmann, however, contends that Olivier de Serres never claimed in his writings that he discovered the sugar content in the beet, and that the statement "that the boiled juice of the red beet was similar in appearance to sugar syrup" cannot be construed as evidence that de Serres actually recognized the presence of sugar in the beet-root.

In the year 1747 Andreas Marggraf, a chemist and a member of the Royal Academy of Science and Literature of Berlin, demonstrated that various kinds of beet-root contained sugar and that the sugar could be extracted and crystallized. This discovery, however, was regarded for many years as being merely a laboratory determination and without practical value. In 1786 Franz Karl Achard, a pupil of Marggraf, attacked the problem

[1] *Quar. Jour. of Economics,* Vol. XVII, p. 1.

of beet-root cultivation and succeeded in extracting sugar from beets on a scale hitherto unknown. He issued a report of the methods employed and the results obtained and stated that a good muscavado sugar should be made from beets for six cents per pound. His claims met with incredulity and no little ridicule, but the French Institute made a careful investigation of what he had done and found that the sugar content of the beets was over 6 per cent. From a number of tests of Achard's process, they estimated that the cost of producing refined sugar from beet-roots on a commercial basis would be eighteen cents per pound.

Frederick William III, king of Prussia, took a keen interest in the making of sugar from beets, and, after having convinced himself that Achard was on the right track, he bought the crown land at Cunern, Silesia, for exploitation on a large scale He provided Achard with funds for the erection of the first real sugar factory built in Germany, at which operations were begun in 1802. The king also supplied money for the construction of other factories in Brandenburg, Silesia, and Pomerania, and lent his support to the growers of beets as well as to the manufacturers of sugar. Despite the reverses in war suffered by the Prussians, the progress in sugar making was so manifest that in 1810 it was clear that the industry was bound to succeed under intelligent management.

Achard, who was of French extraction, had corresponded with a number of scientific men in France and through them reports of his work reached the French Institute. The verdict of this body was favorable and two sugar factories were built, one at St. Ouen and the other at Chelles. Both of these enterprises failed through lack of practical knowledge and the inferior quality of the beet-roots. Although this setback brought the manufacture of beet sugar to a standstill for a time, there is plenty of evidence to show that hope of ultimate success was


FRANZ CARL ACHARD


FIRST BEET-SUGAR FACTORY IN THE WORLD—BUILT AT CUNERN, SILESIA, 1802

never abandoned. The effect of the closing down of these two beet factories was to divert the attention of scientists to making sugar from grapes. Proust and Parmentier, both chemists of note, demonstrated that it could be obtained from this source and the French government issued instructions for the preparation of sugar and syrup from the vine. Parmentier published a bulletin advising against the attempt to make beet sugar in France as the soil of the country would not produce beet-roots containing sugar. In 1810 Napoleon ordered an appropriation of 200,000 francs to be divided as a premium among the factories recovering the highest percentage of sugar from grapes. Meanwhile the friends of the beet movement had not been idle, and early in March, 1811, the Society for the Encouragement of National Industry submitted to the emperor a report of what had been accomplished in the manipulation of beets, together with samples of the sugar obtained, and on the 25th of that month Napoleon issued the edict that established the manufacture of beet sugar in France. The decree provided that 79,000 acres of land in various parts of the empire should be devoted to the raising of beets and directed that all the acreage named should be under cultivation the first year, or at latest the second. It created six experimental stations for the instruction of the farmers and land owners in cultivation and also for the furtherance of the interests of the manufacturer.

Delessert had established a factory at Passy in 1801 and by dogged perseverance, despite many failures, obtained excellent results by a new method of clarification and the use of charcoal. Napoleon visited his plant in 1812 and ordered the construction of ten new factories at once. On January 1, 1813, all further imports of sugar from the East and West Indies were prohibited.

In 1812 and 1813 the output of sugar in France was 2200 tons and the factories of Germany and Austria gave promise of soon supplying the wants of their respective countries. During the

following two years there were unusually heavy rains and the beet fields of France were occupied by hostile troops. The defeat of Napoleon at Waterloo and the consequent abolition of the blockade caused a decline in the price of sugar to a point where the new beet industry was unable to compete and only one factory succeeded in avoiding the general disaster.

From 1816 to 1821 the average yearly output of beet sugar was 1000 tons. The domestic product had a great advantage over the foreign article, as all sugars coming into France from abroad were subject to a heavy duty, while no tax was levied on home-grown sugar. In 1821, a duty of 49.5 francs was imposed upon every 100 kilograms (220.4622 lbs.) of raw sugar coming from French colonies and 70 francs on white sugar. The tax on sugar from foreign countries was 90 francs per 100 kilograms, and this was increased to 125 francs in 1829.

Shortly afterward the surtax[1] on foreign sugar was increased and an extra duty was exacted on sugar brought into France in foreign bottoms. Even with this protection the domestic producers were not satisfied. French colonial sugar, when exported, received the benefit of customs drawback of 120 francs per 100 kilograms, and the same privilege was accorded home-grown sugar upon which no duty whatever had been paid. This was tantamount to an export premium of 120 francs per 100 kilograms, and it may well be imagined that under this paternal arrangement old factories came back to life and new ones sprang into being. Under this régime by 1836 nearly one-third of the sugar refined in France was beet. The payment of this premium was so great a drain on the government treasury that in 1840 the authorities seriously considered the buying up of all the beet-root sugar factories then in operation for forty million francs and the equalizing of the tax on foreign and domestic sugar. The scheme was not carried out, but in 1843 beet-root

[1] The excess of import duty over the domestic revenue tax.

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sugar and cane sugar were placed on the same basis. This hurt the domestic industry severely, and if it had not been for the setback to the cane production by the abolition of slavery, the beet interests might have met with ruin. Nevertheless, in spite of many adverse turns of fortune, the general trend was forward.

Beginning with the year 1836, the beet-sugar industry in Germany, which had been paralyzed by the raising of the Continental blockade, went ahead rapidly. The German manufacturers gradually succeeded in obtaining a higher extraction of sugar from the beet and consequently their operations showed an increased profit. Krause of Austria and Schubarth of Prussia, both of whom had studied beet-sugar making in France, did much by their efforts to rehabilitate the industry in Germany, where it has steadily grown in importance ever since.

The manufacture of beet sugar was revived by Austria in 1831 and by 1840 there were many factories in operation. In 1854 the output of domestic sugar equaled the tonnage brought in from foreign countries and beet sugar had established itself throughout Europe as a strong competitor of the cane sugar of the colonies.

The European consumption, however, had grown at such a rate that the domestic beet-sugar production did not keep pace with it, hence the cane manufacturer was scarcely sensible of the competition for some years; in fact Europe took rather more than less cane from the tropics for a time.

During the nineteenth century Europe became less and less dependent upon the cane countries of the New world for its supplies. The abolition of slavery in most of the European possessions (1825-50), the development of the cultivation of cane in India and Java, and the expansion of the bounty-fed beet-sugar industry in Europe all contributed to bring this about and many colonial cane growers found themselves on the brink of ruin.

Slavery, upon which cane sugar raising so greatly depended, was entirely abolished in British possessions in 1834, in France in 1848 during the Second Republic, in the Dutch West Indies in 1863, in Porto Rico in 1873, in St. Thomas in 1876, and in Cuba in 1880. Great Britain appropriated the sum of £20,000,000 sterling as an indemnity, and of this £16,500,000 went to West Indian planters, the remainder going to Mauritius and the Cape, but indemnification, while most welcome, did not restore the supply of labor. Many of the freed slaves refused to work and great numbers of them left the plantations. British colonists were at a serious disadvantage, too, as after their slaves were liberated slavery still existed in other West Indian islands, and to offset this a special import tax was imposed on sugar produced by slave labor.

Strenuous efforts were made to secure an adequate labor supply. Chinese coolies, free negroes and Hindus were tried, but the cost was great and the number available was insufficient for the proper cultivation and upkeep of the plantations. This condition obtained in the British West Indies, Cuba, Louisiana, Peru, Brazil, the Guianas, Mauritius, Réunion and other places, and the cane growers had hard work to keep from going under during the adjustment period, when they were learning how to operate their plantations with a limited number of hands. Importation of labor, subdivision of cane lands into small tracts, to be rented or sold to farmers—many plans were tried—but naturally under such circumstances development was impossible, and beet sugar, which had been steadily increasing, finally outstripped cane in 1883-84, while in 1899-1900 cane only furnished 34.7 per cent of the world's crop. In 1912-13 the cane tonnage exceeded that of beet by 211,082 tons of 2240 pounds. The great war in Europe has curtailed the production of beet sugar in that country to such an extent that of the world's output for 1915-16 the proportion of cane to beet was roughly as

two-thirds to one-third in favor of the former. The actual figures are:

| | |
|---|---|
| Cane | 10,533,039 tons |
| Beet | 5,986,404 " |
| Excess of cane over beet | 4,546,635 tons |

The following table giving the world's production of cane and beet from 1852 to 1916 will be of interest, but it should be borne in mind that this comparison between beet and cane is not a fair one, because the figures are incomplete as far as cane is concerned.

In some instances in former years, only the quantity exported from a country was included in the world's statistics and the amount consumed at home was left out of the calculations. This is particularly noticeable in the case of India, whose production of over two million tons of sugar annually was omitted from the older estimates as it all went into domestic consumption—while the beet figures were invariably given in full.

The world's crop figures as furnished by Willett & Gray for the period from 1852 to 1916 include British India's production for the last eleven years only:

| YEAR | BEET-ROOT SUGAR TONS | CANE SUGAR TONS | TOTAL TONS | PER CENT CANE SUGAR |
|---|---|---|---|---|
| 1852-53 | 202,810 | 1,260,404 | 1,463,214 | 86.0 |
| 1859-60 | 451,584 | 1,340,980 | 1,792,564 | 74.3 |
| 1864-65 | 529,793 | 1,446,934 | 1,996,727 | 73.5 |
| 1869-70 | 846,422 | 1,740,793 | 2,586,915 | 67.3 |
| 1874-75 | 1,302,999 | 1,903,222 | 3,206,221 | 59.4 |
| 1880-81 | 1,820,734 | 2,027,052 | 3,847,786 | 52.7 |
| 1883-84 | 2,485,300 | 2,210,000 | 4,695,300 | 47.0 |
| 1884-85 | 2,679,400 | 2,225,000 | 4,904,400 | 45.4 |

| YEAR | BEET-ROOT SUGAR TONS | CANE SUGAR TONS | TOTAL TONS | CANE SUGAR PER CENT |
|---|---|---|---|---|
| 1885-86 | 2,172,200 | 2,300,000 | 4,472,200 | 51.4 |
| 1886-87 | 2,686,700 | 2,400,000 | 5,086,700 | 47.1 |
| 1887-88 | 2,367,200 | 2,541,000 | 4,908,200 | 51.7 |
| 1888-89 | 3,555,900 | 2,359,000 | 5,914,900 | 40.0 |
| 1889-90 | 3,536,700 | 2,138,000 | 5,674,700 | 37.7 |
| 1890-91 | 3,679,800 | 2,597,000 | 6,276,800 | 41.2 |
| 1891-92 | 3,480,800 | 3,501,900 | 6,982,700 | 51.6 |
| 1892-93 | 3,380,700 | 3,040,500 | 6,421,200 | 47.3 |
| 1893-94 | 3,833,000 | 3,561,000 | 7,394,000 | 48.2 |
| 1894-95 | 4,725,800 | 3,531,400 | 8,257,200 | 42.7 |
| 1895-96 | 4,220,500 | 2,839,500 | 7,160,000 | 39.6 |
| 1896-97 | 4,801,500 | 2,841,900 | 7,643,400 | 37.2 |
| 1897-98 | 4,695,300 | 2,868,900 | 7,564,200 | 38.0 |
| 1898-99 | 4,689,600 | 2,995,400 | 7,785,000 | 38.5 |
| 1899-00 | 5,410,900 | 2,880,900 | 8,291,800 | 34.7 |
| 1900-01 | 5,943,700 | 3,646,000 | 9,589,700 | 38.0 |
| 1901-02 | 6,800,500 | 4,079,000 | 10,880,500 | 37.5 |
| 1902-03 | 5,208,700 | 4,163,900 | 9,372,600 | 44.4 |
| 1903-04 | 6,089,468 | 4,244,206 | 10,333,674 | 41.0 |
| 1904-05 | 4,918,480 | 4,613,540 | 9,532,020 | 48.4 |
| 1905-06 | 7,217,366 | 6,733,626 | 13,950,992 | 48.2 |
| 1906-07 | 7,143,818 | 7,334,207 | 14,478,025 | 50.6 |
| 1907-08 | 7,002,474 | 6,912,520 | 13,914,994 | 49.6 |
| 1908-09 | 6,927,875 | 7,634,125 | 14,562,000 | 52.4 |
| 1909-10 | 6,587,506 | 8,339,888 | 13,927,394 | 59.8 |
| 1910-11 | 8,560,346 | 8,421,534 | 16,981,880 | 49.5 |
| 1911-12 | 6,820,266 | 9,066,964 | 15,887,230 | 57.0 |
| 1912-13 | 8,976,271 | 9,232,543 | 18,208,814 | 50.7 |
| 1913-14 | 8,908,470 | 9,879,275 | 18,787,745 | 54.3 |
| 1914-15 | 8,241,974 | 10,165,565 | 18,407,539 | 55.2 |
| 1915-16 | 5,986,404 | 10,533,039 | 16,519,443 | 63.7 |

France held the first place in output of beet sugar until 1880, when Germany took the lead and has maintained it ever since. The beet industry assumed important proportions in Austria-Hungary, Russia, Holland and Belgium shortly after 1850, but it was not established in Sweden, Spain and Italy until comparatively recent times.

The laws that were passed by the various European countries for the encouragement and protection of beet sugar were so beneficial in their effect that these countries not only were able to supply their own domestic demand, but found themselves able to export sugar. This stimulation finally led to abuses, as a result of which the Brussels convention was brought about and the bounties abolished.

Apart from certain details, the various regulations in European countries for the purpose of building up the manufacture of beet sugar and making it a revenue producer were very much alike. The essential features were a prohibitive import duty and a slightly lower excise tax. The latter provided revenue for the government, and the difference between the import duty and the excise shut out foreign competition and fixed the amount of profit the domestic beet-sugar producer could make. Still worse, it created pools or combinations for the control of both output and price.

With increased production, which was more than sufficient to supply the home demand, these countries were in a position to export sugar, and in order to enable their manufacturers to compete in outside markets, a drawback of the excise was allowed on all exported sugar. A peculiar condition of the law affecting this drawback was that it really, though not directly, provided for a bounty on export sugar, and while this was not the original intent of the law, the improvements that it encouraged accomplished the purpose.

In Germany the principle was that the excise was levied upon

the quantity of beet-root sliced, while the export drawback was allowed on the actual sugar produced.[1] At the time of the passing of the law that was in operation from September, 1869, to July, 1886, the assumption was that the yield in sugar would be 8.51 per cent of the weight of the beets, allowing 11.75 tons of beets for one ton of sugar, and on all raw sugar exported the manufacturer was given $2.03 per hundredweight drawback, the exact equivalent of the excise tax, which was 17 cents per hundredweight of beets.

For some years after this law became effective it took twelve tons of beets to make a ton of sugar, consequently the drawback allowed the exporter did not represent all of the excise. Thus it became the aim of the manufacturers to raise the sugar content of the beets and to improve the extraction. By 1882 they had succeeded so well that a ton of sugar was produced from 10.46 tons of beet-roots instead of 11.75 tons,as predicated when the law was drawn up. The drawback, however, was still allowed at the rate of $2.03 per hundredweight, which netted the producer a clear gain of 22 cents.[2]

In France from 1864 to 1875 the calculations were made from the quantity and purity of the juice. In other words, a certain arbitrary *rendement*[3] of sugar from the beet-root was the basis of taxation, while any excess recovery was exempt. This was equivalent to an indirect bounty, but the French government saw to it that the estimates and the actual outturn did not get too far apart. No bounty whatever was paid on French sugar from 1875 to 1884.

About 1880 the sugar production of Germany exceeded that of France, so that in 1884 the French authorities revived the indirect bounty system to put new life into the industry, and the effect of this action was soon apparent.

[1] When exported, of course. [2] Roy G. Blakey, Ph. D. *The United States Beet Sugar Industry and the Tariff*, Columbia University, 1912. [3] Actual production in sugar.

Sugar legislation in other sugar-producing countries of Europe was similar in general principles and gave practically the same results. Amendments were made from time to time with a view to bringing the basis provided for in the law closer to what was actually attained in production, but the manufacturers by constantly improving their processes managed to keep the advantage and consequently to receive a secret indirect bounty or rebate.

The payment of these drawbacks taxed the treasuries of the different countries concerned and in the case of Austria-Hungary amounted to more than the entire revenue from sugar. This brought new regulations and the payment of direct bounties instead of hidden or indirect. Furthermore, a limit was set upon the total that could be paid in any one year.

Nevertheless, the producers in all the sugar-raising countries used their utmost efforts to send as much sugar as they possibly could to foreign markets in order to secure the drawback. It naturally followed that the production was stimulated to an abnormal degree, and toward the end of 1883 there was a slump in prices that affected all raisers of sugar, both beet and cane, throughout the world.

The governments of Europe came to find these bounties a serious burden, and when Lord Salisbury arranged for a convention to be held in London in 1886, the proposal to do away with all bounties met with a good deal of favor. France, however, opposed the idea, as she wished to discontinue the direct bounty only and to leave the indirect still in force, while the British themselves, who used prodigious quantities of sugar and who, under the bounty plan, got all they needed at a price below the actual cost of production, did not wish to forfeit this advantage. So the interests of the British colonists were sacrificed and the London conference accomplished nothing.

In 1890 Germany resolved to divest sugar of all its privileges

in order that the treasury should receive the entire amount of the taxes. A measure was proposed in 1891 providing for direct export bounty. This was to be reduced in 1895 and entirely abolished by 1897.

Owing, however, to a severe agricultural crisis at this time, American cereals were brought into Europe at such low prices that the home grower could not compete. It therefore became necessary to find another crop for the land that had been sown to corn and the beet-root was the logical substitute. The increase in beet production from this cause was followed by a crash in sugar prices. With such a condition confronting it, the German government could not do away with, or even reduce, the bounty, especially as none of its neighbors seemed to have any intention of doing anything in this direction. In the interests of the beet growers, the output of beets in 1895, instead of being restricted as proposed, was doubled, and the export bounty on raw sugar was raised from 1.25[1] marks to 2.50 marks per 100 kilograms and on refined from 2 marks to 3.55 marks per 100 kilograms.

This legislation was meant to foster the export trade and bring the sugar business of foreign countries to German manufacturers, and the framers of the law were confident that other countries would not venture to follow suit. In this they were utterly mistaken. Germany's competitors simply raised their bounties to her figures, thus nullifying her plans for expansion of her export sugar trade.

In 1897 the United States levied a countervailing duty on all bounty-nourished sugar, in addition to the regular protective tariff, so that the bounty paid by European countries on sugar exported to the United States simply went to enrich the United States treasury.

The manufacturers of Germany and Austria enjoyed a profit

[1] Mark=23.8 cents U. S. coin.

over and above the bounty by the adoption of what was termed a cartel, or pool, a plan borrowed from Russia.

In Russia the government fixes the amount of sugar required each year for domestic consumption and this quantity may be sold by the manufacturer. Then it determines what quantity shall be kept in reserve, to be sold when the price exceeds that named by the government commission (4.30 rubles[1] per pood[2] in winter, or 4.45 rubles in summer). Should the production exceed the amounts fixed for domestic consumption and reserve, exportation is permitted and the exporter gets back the excise, 1.75 rubles per pood, or if he elects to sell this excess at home, he may do so by paying double tax, or 3.50 rubles per pood. Of the alternatives, exporting the surplus is the more advantageous to the owner of the sugar, as the fixed price for domestic sugar is a profitable one. He therefore can afford to take a loss on the sugar he sells for export and still make money on the total operation. The stipulation that the contingent interest in the profitable home market shall keep pace with the growth of the output of the factory is also a substantial encouragement to manufacturers to increase their production. Regulations like these naturally have the effect of supplying foreign markets with cheap sugar. The manufacturer makes an excellent profit and the domestic consumer pays the entire bill.

Primarily, the intent may have been to keep the price of domestic sugar at one level and to enable the manufacturer to fill the home demand without having to go outside the country for his raw-sugar supply. But the plan in its actual working fosters exportation at the expense of the home consumer.

While in Russia the cartel was a government measure, the pooling of interests by German and Austrian manufacturers in their respective countries accomplished the same end. A cartel formed in Russia in 1890 came to grief after four years

[1] Ruble=51 cents. [2] Pood=36.07 pounds.

through the individual greed of its members. In 1898 a new combination of raw-sugar producers and refiners was formed, with the express proviso that the manufacturers of raws were to sell their product only to refiners who were members of the cartel. The domestic trade in white sugar was prorated among the refiners, in consideration of which they had to allow the producer a fixed price of 30 kronen ($6.08) per 100 kilograms (220.4622 lbs.) for raw sugar, the market price of which was paid by the buyer and the difference by the cartel, which got the money by notching up the price of domestic refined sugar.

With the cartel the only seller of refined, and sugar from foreign countries shut out by the high surtax (the difference between the impost on imported and domestic sugars), the consumer had to pay the price demanded by the cartel as long as the difference between the world's price and that established by the cartel was less than the surtax.

The profit thus obtained constituted a working fund to be used in forcing into line such factory owners as remained outside the pool, either by reducing the price when a factory was about to begin to make white sugar, or by buying stock in the corporations that still held out. Out of the rest of the fund was paid the difference between the market price (with 22 kronen per 100 kilograms as a minimum) and the 30 kronen. Any amount remaining was the cartel's profit. To illustrate and estimating that 110 kilograms of raw sugar produced 100 kilograms of refined:

| | | |
|---|---|---|
| Price of refined sugar for domestic use per 220.4 lbs. | | $17.25 |
| Raw sugar 242.4 lbs. @ $4.46 per 220.4 lbs. | $4.91 | |
| Refining cost and profit | 1.53 | |
| Revenue tax | 7.71 | 14.15 |
| Net profit of cartel | | $3.10 |

| | |
|---|---|
| With an open market price of \$4.46 for raws, the difference between that and the arbitrary figure of \$6.08 is \$1.62 per 220.4 lbs. on 242.4 lbs. | 1.78 |
| Net profit from cartel for refiners | \$1.32 |

Reference has been made to the abortive results of the London conference of 1886, when a deaf ear was turned to the appeal of the planters of the British West Indies on account of the advantage to the British manufacturer and consumer of securing all the sugar they wanted at a figure lower than it cost to produce.

In 1895, Joseph Chamberlain, then Colonial Secretary of Great Britain, appointed a royal commission to investigate conditions in the West Indian colonies. The facts brought out in its report came as a surprise to the statesmen of the mother country and remedial measures were undertaken.

The anxiety of the Austrian and German governments to get rid of the bounty incubus led them to sound France as to her views, and in 1898 the Belgian government invited representatives of Great Britain, Germany, Austria, the Netherlands, France, Russia, Spain and Sweden to meet in conference in Brussels, but no definite agreement was arrived at, chiefly because of France's unwillingness to discontinue the giving of indirect bounty. The meeting adjourned on June 1st with the understanding that it would again convene at the call of Belgium, when the preliminary negotiations through Belgium's good offices had progressed sufficiently to make unanimity possible.

Meanwhile, public opinion in England with regard to the West Indies had undergone a change, partly on account of the report submitted by the Chamberlain commission and partly

owing to the fact that Britain, needing the support of her colonies in her South African war, was anxious to shape her policy to please them.

A third conference was held in Brussels in December, 1901.

In the discussion concerning the German and Austrian cartels, it had developed that the heavy surtax permitted the Germans and Austrians to realize such high prices in their home markets that, even with the bounty repealed, their overproduction was very great and the large tonnage exported by them depressed values in foreign markets. Great Britain and Belgium, therefore, demanded that the surtax be reduced to a point where, while giving protection against foreign sugar, it would afford no inducement for the formation of cartels. Austria and Germany demurred to this and it looked as if a deadlock would again be reached, when Great Britain declared that if nothing came of the conference a measure would be introduced in Parliament excluding bounty-fed sugars entirely, or that some action equally drastic would be taken. It was further pointed out that an extra duty of an amount equal to the cartel profit had already been under consideration by the Indian government.

With a countervailing duty effective in the United States, the market of Great Britain was the only important outlet left for bountied export sugars from the Continent. Then again, the British colonies had to be reckoned with, for if preferential privileges were accorded to their sugars Continental beet would suffer. Great Britain's ultimatum, therefore, carried the day, and on March 5, 1902, the convention was signed by the plenipotentiaries of Great Britain, France, Germany, Austria, Belgium, Spain, Italy, the Netherlands, Norway and Sweden.

The most important provisions of the convention were:

1. The suppression of all bounties, direct or indirect.

2. The limitation of the surtax, *i. e.,* the excess of import

duty over domestic revenue tax, to 53 cents per 100 pounds on refined and 48 cents per 100 pounds on raw sugar.[1]

3. Prohibition of importation of bounty-fed sugar from other countries, unless a countervailing duty is imposed.

4. Great Britain and the Netherlands pledge themselves that no preferential treatment will be given sugar from their colonies during the life of the agreement.

5. The agreement to come into force September 1, 1903, and to remain effective for five years from that date, and in case none of the signatory powers notifies the Belgian government of its intention to withdraw, it shall continue to remain in force for one year and so on from year to year.

6. The appointment of a permanent commission charged with supervising the execution of the provisions of the convention.

7. Spain, Italy and Sweden not to be bound by the principal restrictions, so long as they do not export sugar.

Russia declined to come into the pact, stating as her reason that she paid no bounty.

Great Britain's action in joining the Brussels convention aroused a good deal of feeling at home. The contention was made that it worked an injury to the British consumer in causing an advance in prices; it was also argued that the plea put forth in behalf of the West Indies was really instigated by the selfishness of British investors in colonial sugar plantations. The rise in price that followed the convention was stimulated by the shortage in the European beet crop in 1904, and provoked much agitation and dissatisfaction in England, so that it was not certain that Great Britain would be a party to a renewal of the pact upon its expiration.

Subsequently Peru, Luxembourg and Switzerland joined the convention, and the contracting parties were so well satisfied

[1] Six francs and five and one-half francs, respectively, per 100 kilograms.

with results obtained that they extended the agreement for five years beginning September 1, 1908. The conditions were to remain unchanged, except for an amendment that permitted Great Britain to disregard the article that prohibited the importation of bountied sugar, unless paying countervailing duty. This prohibition directly affected Russian sugars, of which England did not wish to be deprived.

Russia joined the convention in 1908, with the understanding that her existing fiscal laws and excise regulations should not be interfered with and that the method of fixing the price of sugar for home consumption should rest undisturbed. On her part, Russia undertook not to export more than one million tons during the next five years outside of Finland, Persia and neighboring Asiatic countries.

The convention with these modifications was thus extended to September, 1913, and on March 15, 1912, it was agreed to prolong it until August 31, 1918, on practically the same conditions as the 1908 convention. Because of the great drought in central Europe in the summer of 1911, there was a shortage of 2,000,000 tons in the beet-sugar crop of 1911-12, as compared with the former year, and, on account of the consequent rise in price, England demanded that the Russian exports be increased. The other signatory powers agreed to this and the amount that Russia was permitted to export in the seven years beginning September 1, 1911, was fixed at 1,650,000 tons.

In August, 1912, Sir Edward Grey gave notice of Great Britain's intention to retire from the convention on September 1, 1913, and on that date she ceased to be a party to it. Nevertheless, after her withdrawal she undertook to observe all the obligations of the convention, and in return the signatory powers agreed not to discriminate against her manufactures of sugar.

The convention stopped exportation of beet sugar at ab-

normally low prices. It was instrumental in lowering the revenue tax, increasing the consumption and abolishing artificial conditions.

The outbreak of the war in Europe in August, 1914, interrupted the operations of the convention, and it remains to be seen whether or not, when hostilities come to an end, it will be renewed and its terms reaffirmed according to procedure customary when peace is concluded between warring nations.

As soon as the industry got on a sound basis, cane began to feel the benefit of the new order of things. Factories that had been closed were put in operation again and new enterprises were undertaken. Up to the year 1880 the manufacture of cane sugar had been conducted in a slipshod manner. The planters were lavishly extravagant and spent their incomes as they made them, giving no thought to putting aside funds for extensions and betterments. Hard times taught them a severe lesson, by which they profited, and with admirable courage they bent all their energies to the improvement of methods of cultivation and cutting down the cost of production. This was particularly true of Java; beginning with 1884, abundant new capital was brought in, experimental stations and laboratories were built and equipped and all that scientific knowledge, energy and sound business judgment could do was done. At the same time Hawaii, Mauritius, Porto Rico and Cuba made extraordinary progress, but each of these countries deserves an individual chapter.

# BEET SUGAR IN THE UNITED STATES

WHILE the manufacture of sugar from beet-roots is one of the foremost industries in the United States today, the early stages of its growth and development were marked by numerous failures and setbacks. The first beginning was made by a company headed by John Vaughn and James Ronaldson, which built a small factory in Philadelphia in 1830, where a few hundred pounds of sugar were produced. Owing to lack of knowledge of beet culture and extraction of sugar from the roots, the venture proved unsuccessful and no further attempt has been made in Pennsylvania.

Northampton, Massachusetts, was the scene of the next experiment in 1838 and 1839 by David Lee Child, who had studied the growth and manufacture of beet sugar in Europe for a year and a half. He succeeded in getting 6 per cent of sugar and 2½ per cent of molasses from the beets and his estimate of the cost of the sugar per pound was eleven cents. After producing 1300 pounds of sugar he abandoned the enterprise.

A report made in 1838 by the Committee on Agriculture, a government body, contains the following statement: "From all the information which the committee have been able to obtain, they are induced to believe that no country in the world is better adapted for the production of sugar beets than most parts of the United States, whether we consider the soil, the climate or the people."[1]

In 1851 John Taylor, who afterward succeeded Brigham Young as president of the Mormon church, was carrying on missionary work in England, and in September of that year he

[1] Surface, G. T., *Story of Sugar,* p. 115.

met Elias Morris, whom he engaged to go to Utah to establish a plant for the manufacture of beet sugar.

Machinery for the purpose was purchased in France and sent to Liverpool, from where it was shipped to New Orleans in charge of Morris in March, 1852. From New Orleans it was taken up the Mississippi river to St. Louis, thence to Kanesville, Ohio, where it was loaded on wagons for transportation across the plains. The journey from the river was begun on July 4th, with oxen as the motive power. It proved long and arduous, but the members of the party reached Green river, Wyoming, four months later, having suffered much from hunger and cold. There they were met by a detachment sent out from Salt Lake city by Brigham Young and they finally arrived at their destination about the middle of November.

The original intention was to start operations at Provo, and the sugar machinery was taken there, but the company that John Taylor had organized was dissolved and the machinery turned over to the church, under whose direction it was installed in an adobe building still standing in Salt Lake city.

Once more lack of knowledge resulted in failure. Instead of sugar, the Mormons only succeeded in making a massecuite that was utterly inedible.[1]

In 1856, a coppersmith named Bepler erected a small beet-sugar factory at Ocean View, near San Francisco, California, but the enterprise was unsuccessful.[2]

The next noteworthy attempt was made at Chatsworth, Illinois, in 1863 by the brothers Gennert, who came from Braunschweig, Germany, and who were familiar with the methods of beet-sugar making. They formed the Germania Beet Sugar company, planted a thousand acres of land in beets and sent to Europe for machinery, but their highest extraction of sugar

[1] *Hardwick Committee Hearings,* 62nd Congress, 1st Session, p. 767. [2] Truman G. Palmer.

from the beet-roots was only 5.5 per cent. Weather conditions were unfavorable and the soil they selected was not suited to beet culture, so six years of effort ended in failure and the loss of more than a quarter of a million dollars. The plant was removed to Freeport, Illinois, where the final result was disaster.

Otto and Bonesteel, two Germans, established a factory at Fond-du-lac, Wisconsin, in 1866,[1] and during the two following years they achieved some measure of success. Subsequently, they moved to Alvarado, California, where they began operations in 1870. They managed to keep their factory running for a few years, but finally gave up the struggle in 1876.

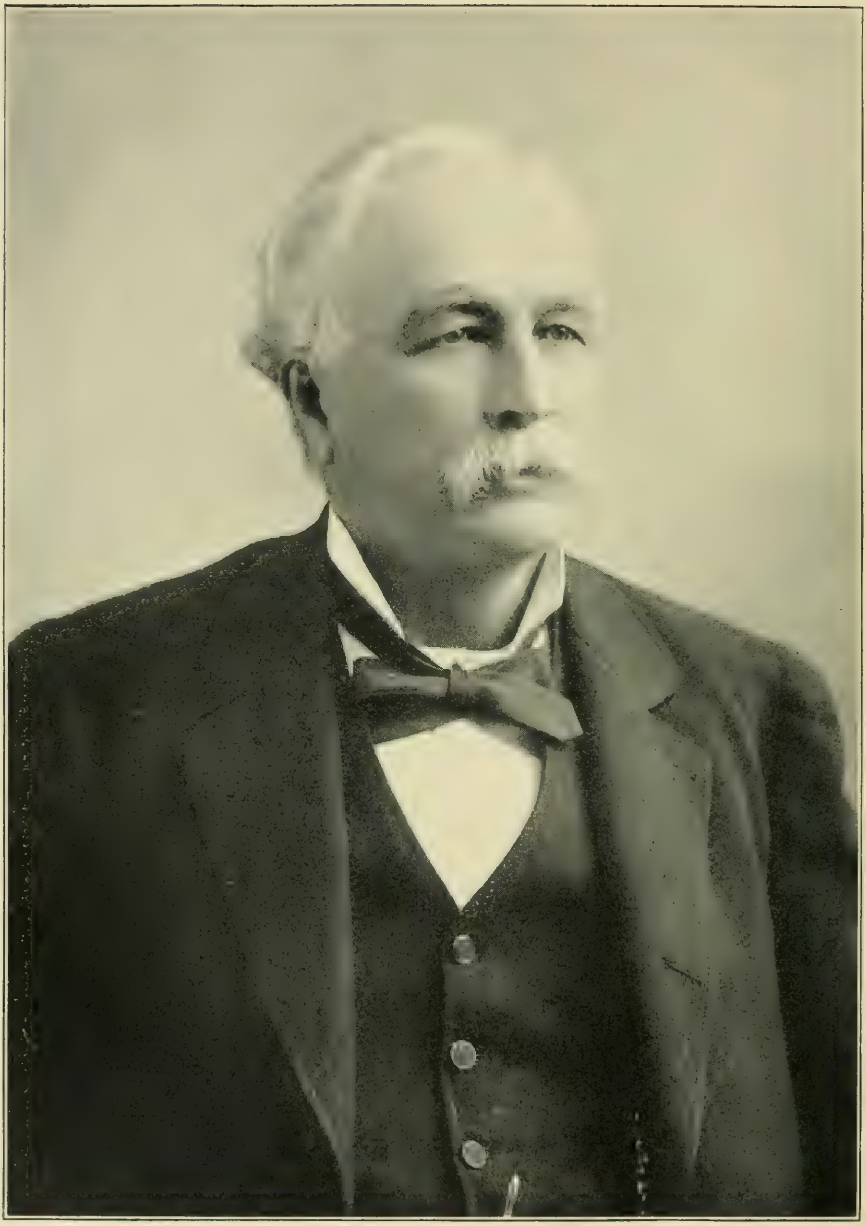
In 1872 the state of New Jersey passed a law providing that all capital and property employed in the raising of sugar beets should be free from taxation for ten years. New ventures were undertaken in California, Delaware and Maine, and these states stimulated the industry by bounties, or tax exemption, or both. A factory was built at Hartford, Maryland, in 1879, but it was afterward abandoned, and the only going concerns engaged in the manufacture of beet sugar east of the Alleghanies during recent years were the small plants in New York at Rome and Lyons. Dismantled in 1905 and 1911, respectively, part of the machinery of the former was moved to Visalia, California, and the latter plant in its entirety to Anaheim, California.

All of these failures were traceable to the lack of practical knowledge of beet culture and the making of sugar from beet-roots. Then, too, the agricultural lands at first selected were unsuited to the purpose and the seed used up to the year 1890 gave beets of a low sugar content, from 6 per cent to 8 per cent. The development of the Western states gave the beet-sugar industry a permanent place in California, and a little later in Utah, Colorado, Idaho, Montana and Wyoming.

The California Beet Sugar Manufacturing company was or-

[1] Blakey.


BUILDING IN SALT LAKE CITY, UTAH, IN WHICH THE FIRST BEET-SUGAR MACHINERY BROUGHT TO THE WEST WAS INSTALLED



E. H. DYER, THE FATHER OF BEET SUGAR IN AMERICA

ganized by E. H. Dyer and C. S. Hutchinson in 1869 with $250,000 capital and a factory was erected at Alvarado on Mr. Dyer's ranch. Otto and Bonesteel were induced to leave Fond-du-lac, Wisconsin, and come west to assume the management. Operations were begun in 1870 and on November 17th of that year the first beet sugar was made in California. The factory and equipment cost $125,000; the daily capacity was fifty tons of beets and one hundred and twenty-five men were employed. Between one thousand and fifteen hundred acres were planted in beets, the factory paying $3.50 per ton for them. The finished product cost about ten cents a pound, while the market price ranged from twelve to fifteen cents a pound. The first year's output was 250 tons, the second 400 tons, the third 562 tons and the fourth 750 tons. Then financial troubles came and the plant was closed. The machinery was sold to a new concern, which built a factory at Soquel, Santa Cruz county. This enterprise failed in 1876, but the plant was put in operation again in 1880, when 150 tons of sugar were produced. That was the end of the Soquel venture.

In 1879 Mr. Dyer bought the buildings and land of the old California Beet Sugar Manufacturing company, and, with O.F. Giffin, formed the Standard Sugar Manufacturing company, with a capital of $100,000. Subsequently a reorganization was effected under the name of the Standard Sugar Refining company and the capital was increased to $200,000. The machinery and diffusion batteries of a plant built at Brighton by some Sacramento people about eight years previous were purchased and installed at Alvarado in buildings newly erected for the purpose. While it is true that in the operation of this company there was a constant struggle to overcome obstacles and difficulties, it is nevertheless a fact that it achieved success from the beginning. In 1884 the capacity of the mill was increased to 100 tons of beets per day, but disaster overtook the concern

toward the end of 1886. Two of the boilers exploded, making it impossible to operate during the season of 1887-88.

Nothing daunted, Mr. Dyer grappled with the problem once more and succeeded in floating a new corporation, the Pacific Coast Sugar company, with $1,000,000 capital and headed by John L. Howard as president. In 1887 and 1888 this company built the middle part of the present factory at Alvarado, where it installed most of the machinery from the old plant, together with some new apparatus. The campaign of 1888 was barren of results and in March of the following year the Pacific Coast Sugar company sold its property to a new concern, the Alameda Sugar company, whose first president was M. H. Hecht. In 1890 two additions to the factory were built, one at each end.

From small beginnings, this Alvarado enterprise, the pioneer of American success in the production of sugar from beets, continued its yearly operations from 1879 until 1914, with the exception of the year following the boiler explosion. In 1889 the output was 872 tons, in 1911 it reached 9966 tons. At the beginning of 1914, sugar prices were low and tariff prospects very discouraging. Under such conditions, the owners of the plant did not believe that they could make sugar at a profit, and the factory remained closed during that season. The sharp advance in sugar values, due to the war in Europe, completely changed matters; beets were planted and 6363 tons of sugar were produced in 1915.

For a long time Mr. Dyer was looked upon as an enthusiast and a dreamer whose sincerity was unquestioned, but whose energies were misdirected. In the midst of the gloomy forebodings of those around him, he held tenaciously to his purpose and devoted his brains and his money to the solution of the problem confronting him. That the beet-sugar industry of the United States proved a success when it did is due to his unfailing courage and persistent effort.

A year before the Alvarado factory was built, a number of moneyed men of Sacramento, head by Julius Wetzlar, then president of the Capital savings bank, conceived the idea of starting a beet-sugar plant there. After some experimenting with local beets, the Sacramento Valley Sugar company was organized and machinery for a seventy-ton plant was ordered from Germany. Construction was delayed for a year, and thus the Sacramentans lost the honor of being the first in the field. In 1871 they built a factory at Brighton, six miles east of Sacramento, near the American river. An expert was brought out from Germany and work was begun on November 18th. The first diffusion battery used in the United States was employed in the extraction of sugar from the beets. The season of 1871 gave good results, but the following year the crop suffered greatly from the ravages of the army worm. The campaign of 1873 opened on August 5th, lasting until November 22nd. The yield of beets was ten tons per acre, the average sugar content 8 per cent and the total output 982,120 pounds of sugar, including all grades.

This enterprise struggled along until 1875, in spite of troubles from drought, army worm, grasshoppers and last, but not least, lack of experience. The plant was then closed and the equipment put up for sale. Briefly, it may be said that at the outset very poor sugar was turned out, and later, when the quality was improved, the cost of manufacture was found to be greater than what the sugar would bring. The final outcome was that the stockholders lost nearly all the money they had invested.

About 1874,[1] the California Sugar Manufacturing company was formed. Sixty-eight acres of land at Isleton were bought, a factory structure of brick was erected and machinery installed, the total expenditure being about $250,000. Sugar of

[1] Professor George W. Shaw says, 1877: *The California Industry*, Sacramento, 1903, page 11.

good quality was made, but the financial result was disastrous. Isleton land was ill suited to beet culture, as when the Sacramento river was high the beet fields were covered with water. One authority states that the original idea was to manufacture sugar from watermelons, and when it was found that this was not practicable, attention was turned to beets.

In 1876 numerous mechanics' liens were filed against the company. Later, the factory was leased to H. M. Ames of Oakland, who operated it during the campaign of 1880. Two years afterward the entire plant was sold at sheriff's sale for $10,000. The land and building were purchased by P. H. Gardiner of Isleton and the machinery went to a San Francisco junk dealer. This venture is said to have caused financial distress to many of the farmers in the vicinity.

In 1888, Claus Spreckels, so long a prominent figure in the sugar world, established a beet factory at Watsonville, Santa Cruz county, in the rich Pajaro valley. At first its capacity was 300 tons of beets per day, and, the result of the operations being favorable, this was increased from time to time until it reached 1000 tons of beets per day. The Watsonville factory developed into the largest beet plant in America and remained so until 1898, in which year Mr. Spreckels erected a modern 3000-ton plant at Salinas, fifteen miles distant. Since then the new factory has sliced all of the beets grown in that territory and the old one has been dismantled. The capacity of the Salinas plant now is greater than that of any other beet factory in the United States, being 4000 tons per day.

The Oxnard brothers, Henry T., Benjamin, James G. and Robert, with J. G. Hamilton, W. Bayard Cutting and R. Fulton Cutting, organized the Oxnard Beet Sugar company in 1889, and in December of that year broke ground for a beet-sugar factory of 350 tons slicing capacity at Grand Island, Nebraska. In 1891 they built two more, one at Norfolk, Nebraska, and one

at Chino, California, both of the same size as the Grand Island plant. The machinery for the first two factories was bought in France and that for the last one came from Germany. Toward the end of 1897, construction at Oxnard was begun, and in 1899 a consolidation of all these factories was effected under the corporate title of the American Beet Sugar company.

At the close of 1890, sixty years after the first experiment at Philadelphia, there were only three beet-sugar factories in operation in America; those at Alvarado, Watsonville and Grand Island. The total capacity of the three plants was eight hundred tons of beets a day, or ten thousand tons of sugar a year. France in the same period increased her production from 5000 to 770,000 tons a year through favorable legislation providing for the payment of bounties.

In the United States, whenever beet-sugar enterprises have been started, there has generally been some legal provision for payment by the state of bounty on the quantity of sugar produced. The story of how this responsibility was evaded is hardly a pleasant one. In Nebraska, for example, three different legislatures enacted laws providing for bounty on beet sugar, but in each case the following legislature either repealed the act or failed to make appropriations for the necessary funds. In the early nineties, Michigan passed a bounty law which resulted in several beet factories being established in that state, but when the claims for bounty were presented for payment, the state auditor refused to honor them, and his action was upheld by the state supreme court on the ground of unconstitutionality. A similar condition arose in Idaho. Minnesota paid bounties in 1890 and 1899, after which the law was declared unconstitutional.

The McKinley bill of April, 1891, was the first national legislation to encourage the beet industry. It called for a bounty of two cents on each pound of domestic sugar produced test-

ing over 90 degrees, and admitted beet seed and sugar machinery free of duty. This encouraged the Oxnards to build the factories at Norfolk, Nebraska, and Chino, California, of which mention has already been made. At the same time Thomas R. Cutler and his associates put up a beet factory at Lehi, Utah, which state offered a bounty in addition to that granted by the Federal government.

The tariff act of August 28, 1894, abolished the bounty on sugar and fixed an ad valorem duty of 40 per cent. As a result of the loss of the bounty and the financial stress that reigned at that time, no beet factories were started except that at Menominee Falls, Wisconsin, which was a flat failure.

The following résumé of the United States tariffs on sugar since the year 1846 may be found useful for purposes of reference:

Tariff act July 30, 1846: All sugars 30 per cent ad valorem.

Tariff act March 3, 1857, to be effective from and after July 1, 1857: All sugars 24 per cent ad valorem.

Tariff act March 2, 1861, effective April 1, 1861: ¾c per pound on raw, 2c per pound on refined.

Tariff act August 5, 1861: 2c per pound on raw. Sugars above 12 D. S. and not yet refined, 2½c per pound. 4c per pound on refined.

Tariff act July 14, 1862, effective August 1, 1862: Sugars not above 12 D. S., 2½c per pound. Sugars above 12 D. S., not above 15 D. S., 3c per pound. Above 15 D. S., not above 20 D. S., and not stove dried, 3½c per pound. Refined and above 20 D. S., 4c.

Joint resolution of April 29, 1864, in effect for sixty days: Sugars not above 12 D. S., 2½c per pound plus 50 per cent equals 3¾c per pound. Sugars above 12 D. S. and not above

15 D. S., 3c plus 50 per cent equals 4½c per pound. Sugars above 15 D. S. and not above 20 D. S., 3½c per pound plus 50 per cent equals 5¼c per pound. All refined sugars 4c per pound plus 50 per cent equals 6c per pound.

Tariff act June 30, 1864, effective July 1, 1864: Sugars not above 12 D. S., 3c per pound. Sugars above 12 D. S., not above 15 D. S., 3½c per pound. Sugars above 15 D. S., not above 20 D. S., and not stove dried, 4c per pound. All refined sugars and all sugars over 20 D. S., 5c per pound.

Tariff act July 14, 1870, to be effective on and after December 31, 1870, which means January 1, 1871. Later amended by tariff act of December 22, 1870, to be effective immediately: Sugars not above 7 D. S., 1¾c per pound. Sugars above 7 D. S., not above 10 D. S., 2c per pound. Sugars above 10 D. S., not above 13 D. S., 2¼c per pound. Sugars above 13 D. S., not above 16 D. S., 2¾c per pound. Sugars above 16 D. S. and not above 20 D. S., 3¼c per pound. All sugars above 20 D. S. and all refined, 4c per pound.

Tariff act March 3, 1875: Sugars not above 7 D. S., 1¾c per pound plus 25 per cent equals 2.19c per pound. Sugars above 7 D. S., not above 10 D. S., 2c per pound plus 25 per cent equals 2.50c. Sugars above 10 D. S., not above 13 D. S., 2¼c plus 25 per cent equals 2.81c per pound. Sugars above 13 D. S., not above 16 D. S., 2¾c plus 25 per cent equals 3.44c per pound. Sugars above 16 D. S., not above 20 D. S., 3¼c plus 25 per cent equals 4.06c per pound. All sugars above 20 D. S. and all refined sugars, 4c per pound plus 25 per cent equals 5c per pound.

Tariff act March 3, 1883, effective June 1, 1883: Sugars not above 13 D. S. and not above 75-degree polarization, 1.40c per pound and .04c additional per degree or fraction thereof.

Sugars above 13 D. S., not above 16 D. S., 2.75c per pound. Sugars above 16 D. S., not above 20 D. S., 3c per pound. Sugars above 20 D. S., 3½c per pound.

Tariff act October 1, 1890, effective April 1, 1891 (McKinley bill): Bounties effective July 1, 1891. Bounties declared unconstitutional by the United States supreme court: Bounty on domestic productions, sugars testing 80 degrees to 90 degrees, 1¾c per pound. Bounty on domestic productions, sugars testing at least 90 degrees, 2c per pound. All sugar not above 16 D. S., free. All sugar above 16 D. S., duty ½c per pound. All sugar above 16 D. S. from bounty-paying countries, duty 6/10c per pound.

Tariff act August 27, 1894, effective August 28, 1894 (Wilson bill): Bounty on domestic production repealed. All sugars 40 per cent ad valorem. All sugars above 16 D. S. and all sugars discolored, 40 per cent and ⅛c per pound. All sugars from bounty-paying countries, 1/10c per pound additional.

Tariff act July 24, 1897 (Dingley bill): Raws not above 16 D. S. and not above 75-degree polarization, .95c per pound. Each additional degree or fraction thereof, .035c per pound additional. Sugar above 16 D. S. and all refined, 1.95c. All sugars from bounty-paying countries, countervailing duties equal to bounties additional.

Tariff act August 5, 1909 (Payne-Aldrich bill): Raws not above 16 D. S. and not above 75-degree polarization, .95c per pound. Each additional degree or fraction thereof, .035c per pound additional. Sugar above 16 D. S., and all refined, 1.90c per pound. All sugars from bounty-paying countries countervailing duties equal to bounties additional.

Tariff act October 3, 1913, effective March 1, 1914 (Under-

wood bill): Raws testing not above 75-degree polarization, .71c per pound. Each additional degree or fraction thereof, .026c per pound additional. No. 16 D. S. clause repealed. All Philippine sugars to be admitted free. After May 1, 1916, all sugars to be admitted free of duty.

In April, 1916, a bill was passed by Congress repealing the free-sugar clause of the tariff act of October 3, 1913. The President signed the bill on April 27, 1916.

The Democratic party was defeated in 1896 and the following year saw the passage of the Dingley bill, which levied a duty of 1.685 on 96-degree raw centrifugals under 16 D. S. in color and 1.95 on raws over 16 D. S. and on refined sugars. Under the beneficial influence of this law the industry revived and within a period of about two years from the enactment of the bill twenty-four beet factories sprang into being. One-half of the number were unsuccessful[1] because the stimulating provisions of the new tariff caused ventures to be made hastily and without regard to actual conditions. Of the twelve factories that survived, nearly all were situated in California and Michigan.

From 1900 to 1902 the building of beet plants was not so rapid, for the reason that the failures just mentioned and the popular demand for preferential terms for Philippine and Cuban sugars were not exactly encouraging. A 25 per cent preferential was given to Philippine sugars March 8, 1902, and a concession of 20 per cent of the duty was allowed Cuba December 27, 1903; still, notwithstanding the failures and the political agitation, five or six beet factories were erected each year during this period. The number of beet factories operating in the United States in 1915 was sixty-seven and the total daily slicing capacity was 73,320 tons. The acreage harvested was 611,301 acres, ninety-three per cent of which was worked by independent farmers and seven per cent by the factories. The

[1] Secretary of Agriculture, 61st Congress, 1st Session, Sen. Doc. 22, p. 8.

total amount of beets sliced during that season was 6,150,293 short tons, which produced 874,220 short tons of sugar.

The following is a list of the factories themselves:

| | | DATE BUILT | SLICING CAPACITY |
|---|---|---|---|
| | ARIZONA | | |
| Southwestern Sugar & Land Co.[1] | Glendale | 1903 | 600 tons |
| | CALIFORNIA | | |
| Alameda Sugar Co. | Alvarado | 1870 | 750 " |
| American Beet Sugar Co. | Chino | 1891 | 900 " |
| American Beet Sugar Co. | Oxnard | 1898 | 3000 " |
| Anaheim Sugar Co. | Anaheim | 1911 | 800 " |
| Holly Sugar Co. | Huntington Beach | 1911 | 1200 " |
| Los Alamitos Sugar Co. | Los Alamitos | 1897 | 800 " |
| Santa Ana Co-op. Sugar Co. | Dyer | 1912 | 1000 " |
| Southern California Sugar Co. | Santa Ana | 1909 | 600 " |
| Spreckels Sugar Co. | Spreckels | 1899 | 4000 " |
| Union Sugar Co. | Betteravia | 1898 | 900 " |
| Sacramento Valley Sugar Co.[1] | Hamilton City | 1906 | 700 " |
| San Joaquin Valley Sugar Co. | Visalia | 1906 | 450 " |
| Pacific Sugar Co.[1] | Corcoran | 1908 | 600 " |
| | COLORADO | | |
| American Beet Sugar Co.[1] | Lamar | 1905 | 400 " |
| American Beet Sugar Co. | Las Animas | 1907 | 800 " |
| American Beet Sugar Co. | Rocky Ford | 1900 | 1600 " |
| Great Western Sugar Co. | Brush | 1906 | 1100 " |
| Great Western Sugar Co. | Eaton | 1902 | 1000 " |
| Great Western Sugar Co. | Fort Collins | 1903 | 2000 " |
| Great Western Sugar Co. | Fort Morgan | 1906 | 1150 " |
| Great Western Sugar Co. | Greeley | 1902 | 1000 " |
| Great Western Sugar Co. | Longmont | 1903 | 2000 " |
| Great Western Sugar Co. | Loveland | 1901 | 1800 " |
| Great Western Sugar Co. | Sterling | 1905 | 1000 " |
| Great Western Sugar Co. | Windsor | 1903 | 1100 " |
| Holly Sugar Co. | Swink | 1906 | 1200 " |
| National Sugar Mfg. Co. | Sugar City | 1900 | 500 " |
| Western Sugar & Land Co. | Grand Junction | 1899 | 600 " |

[1] Closed.

| | | DATE BUILT | SLICING CAPACITY |
|---|---|---|---|
| | IDAHO | | |
| Amalgamated Sugar Co. | Burley | 1912 | 725 tons |
| Utah Idaho Sugar Co. | Blackfoot | 1904 | 860 " |
| Utah Idaho Sugar Co. | Idaho Falls | 1903 | 950 " |
| Utah Idaho Sugar Co. | Sugar | 1904 | 900 " |
| | ILLINOIS | | |
| Charles Pope | Riverdale | 1905 | 450 " |
| | INDIANA | | |
| Holland St. Louis Sugar Co. | Decatur | 1912 | 800 " |
| | IOWA | | |
| Iowa Sugar Co.[1] | Waverly | 1907 | 500 " |
| | KANSAS | | |
| Garden City Sugar & Land Co. | Garden City | 1906 | 900 " |
| | MICHIGAN | | |
| Continental Sugar Co. | Blissfield | 1905 | 900 " |
| German American Sugar Co. | Bay City | 1901 | 1500 " |
| Holland St. Louis Sugar Co. | Holland | 1899 | 400 " |
| Holland St. Louis Sugar Co. | St. Louis | 1903 | 600 " |
| Menominee River Sugar Co. | Menominee | 1903 | 1150 " |
| Michigan Sugar Co. | Alma | 1899 | 1400 " |
| Michigan Sugar Co. | Bay City | 1899 | 1400 " |
| Michigan Sugar Co. | Caro | 1899 | 1200 " |
| Michigan Sugar Co. | Crosswell | 1902 | 700 " |
| Michigan Sugar Co. | Carrollton | 1902 | 900 " |
| Michigan Sugar Co. | Sebewaing | 1902 | 850 " |
| Owosso Sugar Co. | Lansing | 1901 | 600 " |
| Owosso Sugar Co. | Owosso | 1903 | 1200 " |
| Mt. Clemens Sugar Co. | Mt. Clemens | 1902 | 600 " |
| Western Sugar Refining Co.[1] | Marine City | 1900 | 600 " |
| West Bay City Sugar Co. | West Bay City | 1899 | 900 " |
| | MINNESOTA | | |
| Minnesota Sugar Co. | Chaska | 1906 | 700 " |
| | MONTANA | | |
| Billings Sugar Co. | Billings | 1906 | 2000 " |

[1] Closed.

| | | DATE BUILT | SLICING CAPACITY |
|---|---|---|---|
| | NEBRASKA | | |
| Scottsbluff Sugar Co. | Scottsbluff | 1910 | 1850 tons |
| American Beet Sugar Co. | Grand Island | 1890 | 400 " |
| | NEVADA | | |
| Nevada Sugar Co.[1] | Fallon | 1911 | 600 " |
| | OHIO | | |
| Continental Sugar Co. | Fremont | 1900 | 500 " |
| Continental Sugar Co. | Findlay | 1911 | 800 " |
| German American Sugar Co. | Paulding | 1910 | 900 " |
| Ottowa Sugar Co. | Ottowa | 1912 | 600 " |
| Toledo Sugar Co.[1] | Toledo | 1912 | 1100 " |
| | UTAH | | |
| Amalgamated Sugar Co. | Lewiston | 1905 | 900 " |
| Amalgamated Sugar Co. | Logan | 1901 | 750 " |
| Amalgamated Sugar Co. | Ogden | 1898 | 750 " |
| Utah Idaho Sugar Co. | Elsinore | 1911 | 620 " |
| Utah Idaho Sugar Co. | Garland | 1903 | 950 " |
| Utah Idaho Sugar Co. | Lehi | 1891 | 1165 " |
| Utah Idaho Sugar Co. | Payson | 1913 | 700 " |
| Layton Sugar Co. | Layton | 1915 | 450 " |
| | WISCONSIN | | |
| Chippewa Sugar Refining Co. | Chippewa Falls | 1904 | 500 " |
| Rock County Sugar Co.[1] | Janesville | 1904 | 600 " |
| U. S. Sugar Co. | Madison | 1906 | 600 " |
| Wisconsin Sugar Co. | Menominee Falls | 1901 | 600 " |
| | WYOMING | | |
| Sheridan Sugar Co. | Sheridan | 1915 | 750 " |
| Total capacity (76) U. S. factories | | | 73,320 tons |

[1] Closed.

## TERRITORY OF HAWAII

THE Hawaiian islands lie in the north Pacific ocean, between 18 degrees 54 minutes and 22 degrees 15 minutes north latitude and 154 degrees 50 minutes and 160 degrees 30 minutes west longitude. The group consists of eight inhabited islands and a number of small barren islets extending several hundred miles in a west-northwesterly direction.

The area of the various inhabited islands in square miles is as follows:

| | |
|---|---|
| Hawaii | 4210 |
| Maui | 728 |
| Oahu | 600 |
| Kauai | 547 |
| Molokai | 261 |
| Lanai | 139 |
| Niihau | 97 |
| Kahoolawe | 69 |
| Total | 6651 |

All of them are of volcanic and comparatively recent origin, and their age, or at least the time since the last eruptions on them, decreases from west to east. On Hawaii, the largest and most easterly of the group, the volcanic forces are still active and its surface is covered with lava thrown up at no very remote period. The principal port is Hilo and the highest mountain peaks are Mauna Kea (White mountain), 13,823 feet, and Mauna Loa (Great mountain), 13,675 feet.

Maui is formed by two mountains connected by an isthmus. Mauna Haleakala, the higher of the two, rises to a height

of 10,032 feet.[1] Kahului is the most important town and seaport.

Oahu is of irregular quadrangular shape. Two nearly parallel mountain ranges traverse it from southeast to northwest and between them is a plateau that slopes down to the sea both in a northerly and southerly direction. The principal port is Honolulu, the "cross-roads of the Pacific," a flourishing city of about 60,000 inhabitants and the capital of the group. It is admirably situated on a fine harbor and, in addition to its commercial importance, is one of the most attractive spots in the world on account of its balmy climate and wondrously beautiful surroundings. It is strongly fortified and a considerable military force is maintained there.

Pearl Harbor lies about seven miles from Honolulu in a westerly direction. Here the United States government has established a great naval station, one of the finest in existence. It has the most improved apparatus for supplying coal or fuel oil to vessels; there are machine shops, storehouses and barracks; and the huge dry-dock when completed will accommodate the largest dreadnaughts. The entrance from the sea has been dredged to make it navigable for ships of the greatest draft and the station is protected by powerful long-range guns of the most modern type.

Kauai, the oldest island of the group, is irregularly circular in shape, with a maximum diameter of about 25 miles. On the northwest a precipice rises to a height of 2000 feet and beyond that is a mountain plain, but the other portion of the island consists of shore plains with the mountain peak, Waialeale, 5250 feet high, in their midst. The shore plains are broken by ridges and broad, deep valleys and the island is well watered on all sides by mountain streams. There are a number of ports, but no large towns.

[1] Height of these mountains taken from U. S. Geodetic Survey, March, 1915.

The climate of the Hawaiian islands near sea-level does not vary greatly from one year's end to the other. It is cooler than other regions in the same latitude and extremely healthful. The northeast trade winds blow with periodic variations from March to December, or, as one writer says, 264 days out of 365 every year.[1] The leeward coast, protected by high mountains, is refreshed by regular land and sea breezes. The heaviest rainfall is from January to May, and naturally the greatest precipitation takes place on the windward side of the principal islands. The extremes of local rainfall in the larger islands have been known to range from 12 inches to 300 inches for the year. In Honolulu the average temperature runs from 72 degrees to 74 degrees, the maximum about 88 degrees and the minimum 52 degrees Fahrenheit. In ascending the mountains a lower temperature will be encountered as a matter of course and some of the highest mountain peaks are covered with snow nearly all the year round. Winds seldom blow with extreme violence and hurricanes are unknown.

Singular it is that so little should have been written upon a subject so important as the history of the growth of the sugar industry of the Hawaiian islands. Jarves and Thrum bring the narrative down to 1875 and Mr. H. P. Baldwin, in his book entitled "The Sugar Industry in Hawaii" (1895), contributes a fund of valuable information which is freely drawn upon in this chapter.

Tradition has it that a Japanese junk touched at the island of Maui during the thirteenth century and a Spanish vessel is said to have put in on the south coast of Hawaii during a voyage from Mexico to the Philippines in 1550. Be this as it may, our knowledge of these islands dates only from the time of their discovery by Captain Cook in 1778. He found sugar cane growing there when he landed and speaks of it in his description of

[1] Geerligs, *World's Cane Sugar Industry*, p. 345.

his first visit as being "of large size and good quality." According to the old natives, it grew wild and luxuriant in the valleys and lowlands. As far back as 1837 Mr. D. D. Baldwin recalls having seen fields of white cane on the edge of the woods at Hana, Maui, at an elevation of 2000 to 3000 feet. The natives made no attempt to use sugar cane except as an article of food, although it is said that in ancient days it served as an offering to their gods, particularly the god "Mano" (shark).

Cleveland[1] says that upon his first visit to the Sandwich group in 1799 the natives came alongside the ship in canoes bringing many fruits and vegetables, among which was sugar cane.

L. L. Torbert, one of the early planters, in a paper read before the Royal Agricultural Society in January, 1852, claims that the earliest sugar factory was put up on the island of Lanai in 1802 by a Chinaman who came to the islands in one of the vessels trading for sandalwood. He brought with him a stone mill and boilers, and after grinding one small crop and making it into sugar, went away the next year taking his apparatus with him.

Anderson[2] makes a statement that 257 tons of sugar were exported from the islands in 1814, but cites no authority upon which to base his assertion.

According to Jarves[3] the first instance of the manufacture of sugar goes back beyond 1820, but the name of the pioneer planter is unknown. It is certain that at first molasses was manufactured and then sugar some time before 1820.

Don Francisco de Paula Marin made sugar in Honolulu in 1819, the year before the arrival of the first missionaries. Lavinia, an Italian, did the same thing in 1823. His method was to

[1] Cleveland, Richard J., *Narrative of Voyages and Commercial Enterprises,* Cambridge, 1843. [2] Anderson, Rufus, *The Hawaiian Islands,* Boston, 1864. [3] Jarves, James Jackson, *History of the Sandwich Islands,* Honolulu, 1872.

pound the cane with stone pestles on huge wooden trays (poi boards) by native labor, collecting the juice and boiling it in a small copper kettle.

Accounts from various sources agree that the making of sugar and molasses was general in 1823-24. This undoubtedly had direct connection with the manufacture of rum, which was extensively carried on at that time.

In 1828 a considerable amount of cane was raised in the neighborhood of Honolulu and mills were built in the Nuuanu valley and Waikapu, Maui. A pioneer cane grower, Antonio Silva by name, lived at the latter place, and some Chinamen had a sugar mill near Hilo. In those days mills were made of wood, very crudely put together and worked by oxen.

The first attempt at sugar cultivation on a large scale was made at Koloa, Kauai, by Ladd & company, a Honolulu merchant firm, in 1835. This was the beginning of what is now known as the Koloa plantation, and the first breaking of the soil for planting cane was done with a plough drawn by natives. A mill was established here at the same time, and the enterprise was managed by a Mr. Hooper.

As has been said, the general character of the mills was rude and primitive and it continued to be so up to 1850. The rollers were generally of wood and the kettles in which the juice was boiled were whalers' trypots. The buildings were adobe or simple grass huts. Only one grade of sugar was made. The juice was boiled to a thick syrup and put into coolers to grain, after which the granulated mass was packed in mats, bags, boxes or barrels with perforated bottoms for the molasses to drain off. The mills were run by bullocks, horses and in some cases by water power, and were fed by hand, one stalk at a time. The whole process, both in the field and in the mill, was very crude and imperfect.

The value of the sugar exported from the islands from 1836

to 1841 was $36,000 and that of the molasses for the same period $17,130.

An article by the late William Ladd on the "Resources of the Sandwich Islands," published in the "Hawaiian Spectator" for April, 1838, speaks thus prophetically of the manufacture of sugar, then in its infancy:

"It is a very common opinion that sugar will become a leading article of export. That this will become a sugar country is quite evident, if we may judge from the varieties of sugar cane now existing here, its adaptation to the soil, price of labor and a ready market. From experiments hitherto made, it is believed that sugar of a superior quality may be produced here. It may not be amiss to state that there are now in operation, or soon to be erected, twenty mills for crushing cane propelled by animal power, and two by water power."

Just here it may be remarked that at that time the price of labor was a potent argument in favor of making the islands a sugar-producing country, for native labor was available in abundance and the current rate of wages was from 12½ cents to 37½ cents per day, or $2.00 to $5.00 per month.

In an article on commercial development,[1] Thrum says:

"Hawaiian produce in the early days had to seek distant markets, for we find shipments of sugar, hides, goat skins and the first shipment of raw silk moving to New York per the bark *Flora* in 1840. A trial shipment of sugar was sent to France, but it did not offer sufficient encouragement for any renewals. The Sydney market was also exploited with sugar, where it obtained better figures than similar grades of Mauritius."

Between the years 1840 and 1850 a cane field and rude mill in Lahaina, Maui, were owned by David Malo, a well-known Hawaiian, who made molasses and sold it for home consumption. His apparatus consisted of three whaling-ship trypots set up

[1] *Overland Monthly*, June, 1895, p. 620.

on adobe and stone mason work. The crushing was done with wooden rollers, strengthened by iron bands.

In 1841, Kaukini, governor of Hawaii, planted about one hundred acres of cane in Kohala and the crop when harvested was ground under contract by a Chinese named Aiko.

In Wyllie's "Notes" on the islands, published in the "Friend," December, 1844, the quantity of sugar exported from the island of Kauai is estimated at about 200 tons, and the molasses at 20,000 gallons. Hilo, in the same year, exported 42 tons of sugar. Maui had, at that time, two mills, but the amount of sugar produced is not reported.

In 1851, D. M. Weston, then manager of what is now the Honolulu Iron Works, invented the first centrifugal machine for drying sugar, and this machine was installed on the East Maui plantation in the same year. This, it is claimed, was the first centrifugal to be used for the purpose anywhere.

Prominent among the early planters are the names of Stephen Reynolds, William French, Ladd & company, Dr. R. W. Wood, L. L. Torbert, W. H. Rice, and later on S. L. Austin, A. H. Spencer and Captain Makee.

In the year 1854 or 1855, Captain Edwards of the American whaler *George Washington* brought from Tahiti two varieties of cane, one known as Cuban and the other as Lahaina. The latter proved to be profitable to raise and fifteen or sixteen years later began to displace other species throughout the islands. Since then its popularity continued to increase and up to twenty years ago it was the variety most in favor on all Hawaiian plantations.

Twelve varieties of cane were imported from Queensland, Australia, in 1880, but of these only one—the Rose Bamboo—compared with the Lahaina in productiveness, and that only in high altitudes.

In 1898 Lahaina and Rose Bamboo seemed to have outlived

their usefulness on the Hamakua coast of the island of Hawaii, and while they continued to give excellent results in the low, sheltered valleys, it became evident that they could not be profitably grown on the uplands. The yields in the Hamakua region were becoming smaller each year and the plantation owners had to seek a new variety. A cane known as Yellow Caledonia[1] solved the difficulty and wonderful crops of it have been raised uninterruptedly in that section ever since.

In 1856 no fertilizers were used and practically nothing was known of irrigation. The average yield of sugar at that time was one ton per acre. The extraction of sugar from the cane was less than 50 per cent, while today in the best mills it exceeds 98 per cent and the average result from all Hawaiian factories shows over 90 per cent.

The industry struggled along under severe handicaps and discouraging circumstances until 1857, when the number of plantations on the islands had dwindled down to five: Koloa and Lihue on Kauai, the East Maui and the Brewer on Maui and a Chinese outfit near Hilo, Hawaii.

In 1858-59 steam was adopted as the motive power in the

[1] From what Mr. Noël Deerr, the sugar technologist at the Honolulu experiment station, writes on the subject, it would appear that Yellow Caledonia cane is identical with White Tanna. The three varieties of Tanna cane, the Striped, the White and the Black, are called after the island of that name, one of the Loyalty group, of which the most important is New Caledonia. All of the Tanna canes are cultivated extensively in Australia, and the White Tanna or Yellow Caledonia was brought to Hawaii from Queensland.

Mr. W. P. Naquin, agriculturist of the H. S. P. A. experiment station, Honolulu, says: "Yellow Caledonia cane was first grown in the Kau district by manager George C. Hewitt of the Hutchinson Sugar company. The cane first came into prominence in the early nineties when Rose Bamboo, which had replaced Lahaina cane, began to show signs of deterioration. Yellow Caledonia, being a hardier cane than any of the varieties then grown, and therefore less susceptible to attack of leaf-hoppers and to prevalent diseases, soon gained favor in Kau, from which district it spread to Olaa and the Honokaa district. The introduction of Yellow Caledonia cane was, no doubt, a great help, if not the salvation of the Onomea Sugar company and the rest of the plantations in the island of Hawaii, which suffered so severely from leaf-hoppers and the deterioration of the Lahaina cane."

mills; wooden mills were superseded by those built of iron and in 1861 the first vacuum pans were introduced. The same year saw the number of plantations increase to twenty-two, nine of which employed steam for the grinding of the cane.

The outbreak of the Civil war in the United States cut off the supply of sugar drawn from the Southern states and caused the price of Hawaiian sugar in kegs to advance to ten cents a pound. This gave the Hawaiian producers their first real start. In 1863 the export tonnage was 2600, and this increased until in 1866 it reached 8869 tons.

A small plantation was started at Paia, Maui, by a Captain Bush in 1868 and in the following year he disposed of it to S. T. Alexander and H. P. Baldwin. The former gentleman was then manager of the Haiku plantation and the acquisition of his interest in the Paia venture necessitated his going to Honolulu to borrow the sum of $9000, which he managed to do, but not without difficulty. Mr. Alexander was the father of irrigation in Hawaii. He promoted and built the Haiku ditch, which was the forerunner of the present magnificent water-distributing system of the islands.

The period from 1869 to 1876 was one of arduous struggle for the planters. Their very existence was at stake. The duty levied on imports by the United States cut their margins down to nothing, labor was scarce and the cost of obtaining it great, the rate of interest was from ten to twelve per cent, agents' commissions for buying and selling ran from five to ten per cent; in short, many plantations were threatened with utter ruin, and so seriously discouraged did the business men become that the only gleam of hope for the salvation of the sugar industry seemed to be annexation.

Repeated efforts were made to negotiate a reciprocity treaty with the United States. Finally this was accomplished; the treaty was consummated in 1876 and a new Hawaii was born.

The expansion that followed was more rapid than the finances of the country could stand. Depression ensued, and as a result the resources of the islands were taxed to the utmost.

The demand for labor during this period of expansion was so great that the pay of the laborers in the fields was raised to one dollar a day, with free rent, fuel and medical attendance. Laborers were sought for in the far corners of the earth, and in consequence the islands have a race mixture rarely found anywhere else in the world.

In 1876 the annual crop of the islands could have been put in one vessel of the capacity of those that are now engaged in freighting Hawaiian raw sugars to the United States, the total being in the neighborhood of 13,000 short tons. At that time, however, this seemed an enormous amount to the planters with their small acreage and mills. It is well known that one planter was very much exercised as to how he was possibly going to handle the extraordinary production of 1100 tons from his plantation, which was then the largest in the islands.

The crop came on the market in such small quantities that it was of no value to refiners, as they could not depend upon definite deliveries. It was therefore put up in special containers, known as "island kegs," and sold directly to the wholesale grocers on the Pacific coast.

Some plantations turned out sugars that found especial favor with the trade, and these grades brought as high as 14 cents per pound.

Under the benefits of reciprocity the crop increased by leaps and bounds and in a short time the planters ceased selling these raw grocery sugars and turned their attention to supplying the wants of refiners. The "island keg" became a thing of the past and the small sailing vessels which had heretofore carried all the island products to the mainland gave way to steamers. At the present day there is only one sailing vessel plying regularly

between San Francisco and the islands, and she usually loads at a port where the large freighting steamers do not care to venture.

Annexation to the United States in 1898 was the next important step in the development of Hawaii. Its immediate effect was to create a feeling of security and confidence in every direction, for while the reciprocity treaty had produced excellent results, the danger of its being made the subject of attack in Congress was ever present. The hoisting of the American flag in the islands permanently dispelled any anxiety on that score.

Of all the early pioneers whose steadfastness and courage kept the sugar industry alive through so many vicissitudes, but few survive. Their descendants have succeeded to their possessions and responsibilities, and today in Hawaii cane cultivation and sugar manufacture have attained a higher degree of development than has been reached by any other country in the world. Crude methods and appliances have long since disappeared. Scientific principles govern the treatment of the land and the selection and care of the cane. The irrigation works are marvels of engineering skill. The mills are modern steel-frame structures, with concrete floors and equipped with machinery of the most improved type. And the end is not yet. The minds of many highly trained men are constantly at work upon the various problems presented by the industry, and what the fruit of their effort will be, who shall say?

Production of Hawaii since 1837 in tons of 2240 pounds:

| | | | |
|---|---|---|---|
| 1837 | 2 | 1844 | 229 |
| 1838 | 40 | 1845 | 135 |
| 1839 | 45 | 1846 | 134 |
| 1840 | 161 | 1847 | 225 |
| 1841 | 27 | 1848 | 223 |
| 1842 | ... | 1849 | 292 |
| 1843 | 511 | 1850 | 335 |

| | | | |
|---|---|---|---|
| 1851 | 9 | 1884 | 63,685 |
| 1852 | 312 | 1885 | 76,496 |
| 1853 | 287 | 1886 | 96,528 |
| 1854 | 257 | 1887 | 94,984 |
| 1855 | 129 | 1888 | 105,307 |
| 1856 | 248 | 1889 | 108,110 |
| 1857 | 313 | 1890 | 115,977 |
| 1858 | 538 | 1891 | 122,761 |
| 1859 | 816 | 1892 | 109,178 |
| 1860 | 645 | 1893 | 136,269 |
| 1861 | 1,144 | 1894 | 148,600 |
| 1862 | 1,342 | 1895 | 133,596 |
| 1863 | 2,363 | 1896 | 201,632 |
| 1864 | 4,649 | 1897 | 224,200 |
| 1865 | 6,838 | 1898 | 204,834 |
| 1866 | 7,915 | 1899 | 252,506 |
| 1867 | 7,646 | 1900 | 258,522 |
| 1868 | 8,175 | 1901 | 321,463 |
| 1869 | 8,171 | 1902 | 317,510 |
| 1870 | 8,386 | 1903 | 391,063 |
| 1871 | 9,715 | 1904 | 328,103 |
| 1872 | 7,587 | 1905 | 380,579 |
| 1873 | 10,326 | 1906 | 383,226 |
| 1874 | 10,967 | 1907 | 392,872 |
| 1875 | 11,197 | 1908 | 465,288 |
| 1876 | 11,640 | 1909 | 477,818 |
| 1877 | 11,418 | 1910 | 461,687 |
| 1878 | 17,157 | 1911 | 506,090 |
| 1879 | 21,884 | 1912 | 531,480 |
| 1880 | 28,386 | 1913 | 488,212 |
| 1881 | 41,870 | 1914 | 550,926 |
| 1882 | 50,572 | 1915 | 577,183 |
| 1883 | 50,941 | 1916 | 545,000 |

# LOUISIANA

THE cane crop of Louisiana comes from the southern part of the state, principally along the banks of the Mississippi, the Bayou Teche and the Bayou Lafourche. As this region is outside the tropics, being between 29 degrees and 31 degrees north latitude, frosts must be looked for in winter. The sugar industry of Louisiana, therefore, as well as that of Texas, Florida and Georgia, has to cope with climatic conditions that are unknown in most other cane-producing countries.

All of the sugar plantations are situated in the low plains, the highest elevation above sea-level not exceeding 83 feet. The annual rainfall varies from 67 to 95 inches, and 80 inches may be taken as a fair average, which amply suffices for the needs of the growing cane. In December, January and February there is always the danger of frost and planters must be constantly alert to guard against this as far as possible. During the autumnal equinox much damage to the cane is caused by hurricanes that rush in from the Gulf of Mexico.

Sugar cane was brought to Louisiana in 1751. According to Gayarré, two ships that were transporting troops from France to Louisiana touched at a port in Hispaniola during the voyage and the Jesuits of the island obtained permission to put some sugar cane on board these vessels to be taken to Louisiana and there delivered to their Jesuit brethren.

The same means were employed to send a number of negroes to cultivate the cane, which was planted according to direction on a piece of ground belonging to the order situated just above the present course of Canal street, New Orleans. The cane grew to maturity and was sold in the market as a luxury.

In 1759 a rich colonist, Dubreuil by name, built a mill and attempted to make sugar, but his efforts were unsuccessful and the idea was abandoned. *Tafia*, a kind of rum, was made from sugar cane shortly afterward.

In 1791 Don António Mendez, an officer of the Spanish crown who lived in St. Bernard parish, bought from a Spanish refugee from Santo Domingo named Solis his land, crop of cane and distilling outfit and attacked the problem with a firm determination to conquer it. He called in a Cuban sugar maker named Morin to assist him, but whether it was that he lacked the means to erect a proper factory, or whether he became discouraged, the fact remains that he only succeeded in turning out a few small barrels of sugar. There is evidence that he did something in the way of refining as well, but not in an appreciable quantity.

The first crop of sugar sufficiently large and profitable to serve as an incentive to others was raised by Etienne de Boré about 1794. Of this achievement Gayarré says: "When the whole agricultural interest of Louisiana was thus prostrated and looking around for the discovery of some means to escape from annihilation, and the eager and anxious inquiry of every planter was 'What shall I do to pay my debts and support my family?', the energy of one of the most spirited and respected citizens of Louisiana suddenly saved her from utter ruin and raised her to that state of prosperity which has increased with each successive year."[1]

In 1794 de Boré purchased seed cane from Mendez and Solis and after planting it he went ahead with his preparations for harvesting, crushing and manufacturing. The following year the sugar he produced sold for $12,000, a considerable sum of money in those days. The boiling of the sugar juice to grain was done under the direction of Antoine Morin, the former as-

[1] Written in 1851.

sociate of Mendez. The method was naturally very primitive, the mill being driven by animal power, and much sugar was lost in the bagasse.

Following the example of de Boré, many planters set out cane and built sugar mills. Their operations were highly successful and they all became wealthy within a comparatively short period.

The industry continued to flourish and prosper, and the year 1820 marked a decided step forward. Up to that time the only two kinds of cane that had been grown in Louisiana were the Creole (from Malabar or Bengal) and the Tahiti. The cane originally planted by de Boré and from which he made his first sugar was the Creole; the Tahiti variety was not introduced from Santo Domingo until 1797. It became patent to the planters that neither of these canes was suited to the Louisianan climate, and they set about looking for a hardier plant. Toward the middle of the eighteenth century the purple and striped varieties were brought by the Dutch from Java to the island of St. Eustatius, and from there a quantity of these canes was taken to Savannah, Georgia, about 1814. They throve extremely well and a former resident of Savannah who had moved to Louisiana and become a planter there, having heard about them, secured some for seed purposes. His experiment proved wonderfully successful and from this single estate the cultivation of the new canes spread over the entire sugar-producing region. As these varieties could stand greater cold than the Creole and the Tahiti, the planters were able to extend their growing area northward and in this way greatly increase their acreage. As recently as 1897 these canes still constituted the crops of Louisiana with a few exceptions.

Of late years, however, seedling canes obtained from Demerara have come into great favor in consequence of the researches of the botanists at the experiment station. In addition

to an advantage both in cane and sugar over the varieties previously used, the time of vegetation is shorter, so that the canes mature earlier, and this, on account of the short season in which Louisianan cane has to ripen, makes the Demeraran decidedly desirable. It has also been proved that Demeraran cane is better able to resist damage by storms, so that taking it all in all it would appear that the newer varieties are quite likely to displace the older kinds.

Cane is usually planted in the same ground every three years. The crop of plant cane is followed by a crop of ratoons and then maize is put in. As soon as the maize is cut the field is sown with a species of large pea *(Vigna sinensis)* and when summer is over the pea vines and the maize stubble are ploughed under. A month after this is done, furrows are dug about six feet apart and early in October cane is planted once more. In this operation two rows of whole cane stalks are placed in the furrows and covered with five or six inches of earth as a protection against frost. Most of this layer of earth is removed in the spring to help the growth of the young cane shoots. Stable manure, cotton-seed meal, nitrates, phosphates and kainite are used as fertilizers.

Harvesting begins at the end of November, and, weather permitting, the cane is allowed to remain standing in the fields until required for grinding. If, however, the Government Weather Bureau should predict cold, the cane is cut without delay, piled in the furrows and covered with dry cane leaves to prevent it from freezing. Cane stored in this manner keeps well so long as the weather remains cold, but as soon as warm weather comes it rapidly deteriorates.

Labor in Louisiana is both scarce and costly, consequently agricultural machinery is used in the fields as far as possible.

The steam engine was first employed in the crushing of cane in the year 1822. About this time, when slavery was such a tre-

HAULING CANE IN THE FIELDS, LOUISIANA

HAULING CANE IN THE FIELDS, LOUISIANA

mendous factor in the South, sugar raising was marked by a tendency toward the large plantation method. From 1830 to 1840 the number of plantations in Louisiana decreased, but the number of slaves employed on them increased 40 per cent. Later, however, the plantations began to grow in number and by 1853 there were more than fifteen hundred of them, as against 668 thirteen years previous. In those days, each plantation had its own sugar mill, so that 1853 may be taken as close to the high-water mark for the number of mills in the South. With the outbreak of the Civil war, the industry was virtually wiped out of existence, and when its rehabilitation was begun, it was carried on along entirely different lines and the separation of the raising of sugar from the manufacture was gradually brought about. Year by year the small mills were abandoned and the crops of cane raised by the planters, large and small, were brought to the central factory to be worked up. Today, where large plantations still exist, it is the practice to rent subdivisions of land from twenty to fifty acres in size to tenants who grow cane for the central mill.

In 1880 there were 1144 small sugar mills in Louisiana and their output of sugar was 121,886 tons. In 1911, 187 mills handled a crop of 5,930,000 tons of cane which gave 308,439 tons of sugar, and this would have been considerably exceeded had it not been for a disastrous freeze. In 1880, 273 factories used horse power, in 1900 only 5, in 1905 none at all. The advent of the vacuum pan and the consequent abolition of the open-kettle method marked another great advance in manufacturing development. In 1880 about 42 per cent of the sugar produced in Louisiana was turned out by factories equipped with vacuum pans. The government statistics for 1909 show a total of 316,829 tons of sugar boiled in vacuum pans and only 3,678 tons of open-kettle sugar.

As has been said, the growing season for cane in Louisiana

is limited and the harvesting is done before the plant has attained its full maturity. Whether or not this has any effect upon the flavor of the sugar and molasses produced is a moot point. It is none the less true, however, that the Louisiana "Clarifieds" and the so-called New Orleans molasses possess a flavor distinctively their own.

In the plantation fields, too, the scientists have worked wonders. To illustrate the benefit resulting from the application of modern methods to the cultivation of cane, in 1885 the average yield of cane per acre in Louisiana was about three-quarters of a ton, while in 1909 the average yield per acre in cane was about 20 tons, the recovery of sugar per ton of cane over 157 pounds, or 3140 pounds of sugar per acre.

The Louisiana state experiment station was established by the sugar planters at Audubon park, New Orleans, in 1885 and endowed for a term of years. This institution has grown in importance until at the present time it has ample grounds, well-equipped laboratories and a sugar house with an installation of the latest and best sugar-manufacturing machinery, all directed and operated by the students of the institution. Here is carried on the work of developing seedlings, improvement of cane varieties, investigation of cane diseases, together with the study of all questions of bettering plantation and factory methods.

The sugar production of Louisiana in long tons from 1860-61 to the present time is as follows:

| | | | |
|---|---|---|---|
| 1860-61 | 117,431 | 1868-69 | 42,617 |
| 1861-62 | 235,856 | 1869-70 | 44,382 |
| 1862-63 | 43,232 | 1870-71 | 75,369 |
| 1863-64 | 39,690 | 1871-72 | 65,635 |
| 1864-65 | 5,331 | 1872-73 | 55,891 |
| 1865-66 | 9,287 | 1873-74 | 46,078 |
| 1866-67 | 21,074 | 1874-75 | 60,100 |
| 1867-68 | 19,289 | 1875-76 | 72,958 |

| | | | |
|---|---|---|---|
| 1876-77 | 85,102 | 1896-97 | 282,009 |
| 1877-78 | 65,835 | 1897-98 | 310,447 |
| 1878-79 | 106,909 | 1898-99 | 245,511 |
| 1879-80 | 88,836 | 1899-00 | 147,164 |
| 1880-81 | 121,886 | 1900-01 | 270,338 |
| 1881-82 | 71,304 | 1901-02 | 321,676 |
| 1882-83 | 136,167 | 1902-03 | 329,226 |
| 1883-84 | 128,318 | 1903-04 | 228,476 |
| 1884-85 | 94,372 | 1904-05 | 355,530 |
| 1885-86 | 127,958 | 1905-06 | 336,751 |
| 1886-87 | 80,858 | 1906-07 | 188,571 |
| 1887-88 | 157,970 | 1907-08 | 302,855 |
| 1888-89 | 144,878 | 1908-09 | 273,178 |
| 1889-90 | 128,343 | 1909-10 | 269,431 |
| 1890-91 | 215,843 | 1910-11 | 263,308 |
| 1891-92 | 160,937 | 1911-12 | 315,066 |
| 1892-93 | 201,816 | 1912-13 | 137,119 |
| 1893-94 | 265,836 | 1913-14 | 261,337 |
| 1894-95 | 317,306 | 1914-15 | 216,696 |
| 1895-96 | 237,720 | 1915-16 | 122,768 |

# PORTO RICO

PORTO RICO, the most easterly and the fourth in size of the Greater Antilles, lies at the entrance to the Caribbean sea, between 17 degrees 50 minutes and 18 degrees 30 minutes north latitude and between 65 degrees 30 minutes and 67 degrees 15 minutes west longitude. It is about 100 miles long by 36 miles wide and has an area of 3606 square miles.

A range of mountains from 2000 feet to 3700 feet in height runs from east to west. The south slope of the island rises abruptly from the foothills, while on the north the ascent is more gradual and broken to a great extent by rugged spurs and deep ravines. There is but little coastal plain on the north, except at the river mouths, but on the south a considerable stretch of lowlands is found. Although many indentations occur in the coast line, few of them afford safe shelter for ships. There are thirty-nine rivers and a great number of smaller streams, but none of the rivers is navigable for more than a mile or two from the sea.

The climate is healthful and is tempered by the northeast trade winds that, with certain modifications due to local conditions, blow steadily the year round. The mean annual temperature is about 80 degrees Fahrenheit. The rainy season begins in May and ends in November and the average yearly precipitation at the foot of Mount El Yunque on the northeast coast is 120 inches. At San Juan it is 55 inches, while other sections of the island are semi-arid or subject to severe droughts. Porto Rico is particularly free from epidemics. The last case of yellow fever was reported in 1897. Cholera and bubonic plague are unknown, and dysentery diseases, formerly common, are steadily

*A. Moscioni, Photo.*

SUGAR PLANTATION SCENE IN PORTO RICO

*A. Moscioni, Photo.*

SUGAR-SHIPPING PORT, PORTO RICO

decreasing. Like other West Indian islands, it is subject to hurricanes, that of 1899 having been unusually disastrous. The census of 1910 gave the population as 1,118,012.

The soil is fertile and may be divided into three classes. First, the red soil, generally found in the mountains; second, the black soil, containing much humus, and third, the coral sand soil of the coast plains. The black has proved to be the best for sugar cane, although excellent yields have been obtained from the coast lands. Notwithstanding the fact that both soil and climate are well suited to cane cultivation, the extension of the industry is checked by the formation of the country. The hilly character of the island and the comparatively limited transportation facilities do not admit of cane being grown in the interior. All of the modern plantations are near the coast, where sugar can be easily transported to steamers. In the north cane may be raised without irrigation, but in the south, where the greater part of the crop is produced, irrigation is necessary. About 400,000 acres of the surface of Porto Rico are under cultivation and half of this area is devoted to sugar. The cane grows chiefly on the rich alluvial lowlands along the coast. On the southern seaboard there is plenty of good land that has never been planted, but to make this available for agriculture means the construction of costly irrigation works with extensive aqueducts and much tunneling.

Porto Rico was discovered by Columbus in 1493. The name Puerto Rico dates from 1521, when gold was found in the island. The natives suffered cruelly at the hands of their conquerors up to the year 1544, when they were set free by the order of King Charles I of Spain.[1] Out of a population originally estimated at 600,000 only a few hundred remained. Great numbers had died and many had fled to Mexico and Peru, but the Spaniards soon filled their places with African negroes.

[1] Elected emperor of the Roman empire as Charles V.

For three centuries the island was harried by the English, attacked by pirates and freebooters, torn by rebellion among the slaves or terrorized by the fleets of the Dutch, who were intent upon its conquest, so that Spain was kept constantly on her guard to prevent her colony from being wrested from her. This state of affairs naturally did not encourage population. The country could not meet the cost of its administration and the deficit had to be paid out of the revenues of Mexico. Up to 1778 only Spaniards were allowed to settle there, but after that date the privilege was granted to people of other countries, provided they were of the Roman Catholic faith, and in 1815 all restrictions were removed. Foreigners were welcomed to the island and many inducements offered them. Trade with the United States was permitted in 1815, but only in Spanish ships.

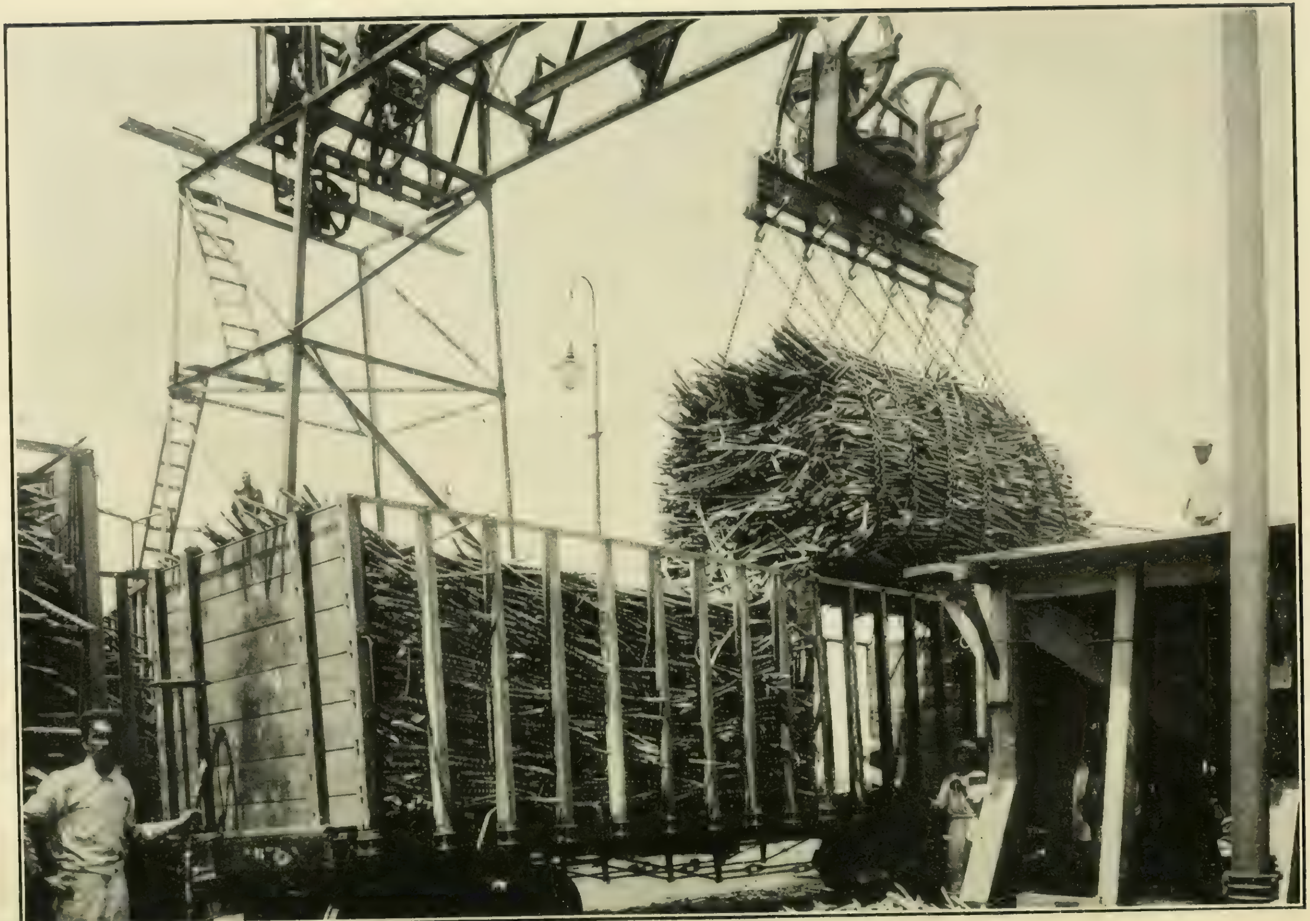
This liberal policy brought many planters from the British and French islands, and as they had experience, capital and slaves, they did much to develop the resources of the colony. Subsequently many refugees came from Haiti, Santo Domingo and Venezuela.

Slavery in Spanish possessions was abolished in 1873 and 34,000 slaves in Porto Rico received their freedom.

After Alphonso XII ascended the Spanish throne in 1875, commercial conditions in the island showed a certain improvement, but politically the situation was deplorable, reflecting as it did all the bad features of an obsolete system of government, complicated by a liberalism that was premature. By reason of its arbitrary decrees and many acts of persecution, the administration stirred up a feeling of bitter antagonism on the part of the colonists. A step toward reform was taken in 1877, when the provincial deputation was re-established, and eighteen years afterward, the home government, in response to vigorous demands from foreign nations, attempted to pass measures to effectively remedy existing evils, but it was far too late. The

PLOUGHING CANE FIELD WITH STEAM PLOUGH, PORTO RICO

*A. Moscioni, Photo.*



*A. Moscioni, Photo.*

UNLOADING SUGAR CANE AT A MILL, PORTO RICO

island received a grant of autonomy in November, 1897, and in July of the following year it was taken over by the United States.

As soon as this became an accomplished fact, there was a marked improvement in conditions, especially from a sugar point of view. Up to this time much attention had been given to the cultivation of coffee, and sugar production had suffered to a certain extent in consequence. Spain had admitted Porto Rican coffee free while protecting it by duties levied on foreign coffee, but when the island passed into the hands of America, this advantage to the coffee raiser disappeared. Besides, the hurricane of 1899 had caused great damage to the coffee plantations and the combination of circumstances proved a severe setback to the coffee industry.

The sugar planters, on the other hand, benefited greatly by annexation. In 1889 the government allowed a reduction of 85 per cent on the duty assessed on Porto Rican sugars entering the United States. In 1901 they came in absolutely free and Porto Rico has enjoyed the full protection of the tariff ever since.

In 1900 Congress passed a law known as the Foraker act, which provided that no corporation should be allowed to acquire more than 500 acres of land in Porto Rico and that no stockholder in any agricultural company operating there should be permitted to hold shares in any other corporation of the kind. The object of the law was, of course, to prevent capitalists from buying up great tracts of land for the cultivation of sugar on a large scale to the detriment of the native land owner.

The act, however, did not serve the interests of the small Porto Rican farmer as its framers apparently intended it should. The owners of large holdings were non-resident and the small farmers lacked the money and enterprise to carry on the industry in a proper manner. The law excluded that which was

most urgently needed, namely foreign capital, and when this fact became apparent, the provisions of the measure were construed liberally by the authorities, so that of late years extensive sugar estates have been started in Porto Rico with American, British and French backing, and the production has grown from 85,000 tons in 1902 to 378,509 tons in 1916.

Formerly the Porto Rican planters used to harvest cane from the same lands year after year, without using fertilizers of any kind. When they planted new cane, the soil was only partially prepared; the subsoil was never cleared of roots and rough grasses and cultivation was only indifferently done. The result is that many cane fields are now practically exhausted and some planters find that their lands are becoming spoiled by rapidly multiplying weeds.

Today the usual method is to plough the ground twice before putting in the seed. Deep ploughing is taking the place of scratching the surface and steam ploughs are being used on the larger estates. Where the soil is heavy and the rainfall abundant, the furrows are dug about eight feet apart and two feet deep and the cane planted in double rows at four-foot intervals. In dry, sandy soil the planting is in single rows and the distance between the furrows ranges from four to six feet, according to how rich the soil is. The fields are kept free from weeds and manure is used but seldom.

The greater part of the cane is planted during the last four months of the year and crushing is begun in the second January following, which gives the cane a growing period of fourteen months or more. Some planting is done in January, February and March and this cane is cut in twelve months. Then a certain amount is planted between March and June, and if the sugar content proves satisfactory, it is ground the following season; if not, it is allowed to remain standing for another year. Planting is done every four years and the best results are ob-

tained from the first and second ratoon crops. The yield of cane per acre averages about 18 long tons, although this has been exceeded in good years. The cane is cut close to the ground with a *machete* and loaded on ox-carts to be taken to the mill or the railway station, according to the location of the field.

Almost all of the cane grown in Porto Rico is ground in the large central factories, but it is only during the last ten or twelve years that this has been done. The small mills have disappeared for the most part, although a few have been able to struggle along.

The centrals usually raise about one-half of the cane they grind. The rest they buy from the *colono,* who grows cane either on his own land or upon ground rented to him by the central owner. As a rule the price paid to the *colono* for his cane is 5 per cent of the weight of the cane in sugar, although this is subject to modification at times. As the central factories are of recent construction, they are equipped with the newest and best machinery and the most scientific methods govern their operation.

In 1853 Porto Rico exported 112,000 tons of sugar; the following year the amount was 70,000 tons and during the next twenty years it remained nearly stationary. In 1871 the production reached 105,000 tons, dropping back to 89,000 tons in 1885 and 65,000 tons in 1886. The crop of 1900 was very small—35,000 tons—owing to the havoc wrought by an unusually severe hurricane, but from that time on it has increased year by year.

As most of the diseases and pests that attack sugar cane are met with in Porto Rico, it is obvious that the work of the United States agricultural station at Mayaquez has been of inestimable benefit to the planters. Experimenting with different varieties of cane, importing seed cane from other countries, analysis of soils, scientific advice upon the use of fertilizers and instruction as to the best means to destroy or control harmful

parasites, these are but a few of the many important services rendered by the station.

The outlook for Porto Rico's sugar industry seems hopeful. Labor is cheap and abundant, climatic and soil conditions are favorable and an irrigation project at present under way promises to convert lands now arid into productive cane fields.

Since 1900 the production of sugar in Porto Rico in tons of 2240 pounds has been:

| | | | |
|---|---|---|---|
| 1900 | 35,000 | 1908 | 200,000 |
| 1901 | 80,000 | 1909 | 245,000 |
| 1902 | 85,000 | 1910 | 308,000 |
| 1903 | 85,000 | 1911 | 295,000 |
| 1904 | 130,000 | 1912 | 320,000 |
| 1905 | 145,000 | 1913 | 350,323 |
| 1906 | 213,000 | 1914 | 325,000 |
| 1907 | 210,000 | 1915 | 308,178 |
| 1916 | 378,509 | | |

# THE PHILIPPINES

THIS group of islands is situated about 500 miles off the southeast coast of Asia, between 4 degrees 10 minutes and 21 degrees 10 minutes north latitude and between 116 degrees 40 minutes and 126 degrees 34 minutes east longitude. It is bounded on the west and north by the China sea, on the east by the Pacific ocean and on the south by the Celebes sea. It comprises 3141 islands, of which 2775 contain less than one square mile each. According to the Philippine census of 1903 the total area is 115,026 square miles,[1] although some authorities estimate it to be as much as 127,800 square miles. Two-thirds of this is forest land and not more than 9½ per cent of the entire archipelago was classified under *Farms* in 1903. The area devoted to sugar cane the year previous was 177,628 acres, about 5 per cent of the cultivated land.

The islands are chiefly of volcanic origin and their surface is much broken by hills, isolated volcanoes and mountain ranges running north and south, northwest and southeast or northeast and southwest. There are twelve active volcanoes in the group and eight others with well-defined cones that are either dormant or extinct. The highest elevation in the islands is Mount Apo, an extinct volcano on Mindanao, 10,312 feet, with Mount Mayon, an active volcano on Luzon, next, 8970 feet. Earthquakes are frequent and occasionally violent.

The most important of the group are Mindanao, Luzon, Samar, Palawan, Panay, Negros, Leyte, Mindoro, Cebú, Masbate and Bohol. The coast line, which is over 11,000 miles in length, is fringed with coral reefs and indented by many gulfs

[1] U. S. War Department. Bureau of Insular Affairs, Washington, 12-16-14.

and bays. There are plenty of good natural harbors, the principal one being Manila in Luzon, which affords perfect shelter for shipping, even in the severest storms. Next in importance are the harbors of Iloilo and Cebú.

Climatic conditions vary widely. However, it may be said in a general way that the climate is characterized by a uniformly high temperature, excessive humidity, heavy rainfall and violent tropical storms. Near the seacoast, it is moderate between November and the first of March. The latter part of March and the months of July, August and September are warm and very hot weather comes in April, May and June. The nights, however, are always cool. The temperature naturally changes as the elevation above the sea increases, but at ordinary levels it averages 77 degrees Fahrenheit in January, and 83 degrees in May.

The annual rainfall is about 74 inches, and two-thirds of this comes in July, August, September and October. Of course the precipitation in certain localities is affected by mountain ranges that cause condensation from moisture-laden trade winds. In the lowlands that are not protected by mountains, the rainfall is regular. Typhoons occur between April and October, but they are not nearly so severe as the hurricanes that visit the West Indies and Mauritius. In October, 1882, a typhoon did a great deal of damage in Manila, and there was a serious loss of life in the great storm that visited Samar and Leyte in 1897. The well-appointed observatory in Manila sends out warnings of the approach of typhoons and much life and property are saved by this means.

The soil is generally reddish-brown in color and is largely made up of disintegrated lava with an admixture of decayed vegetable matter; sometimes decomposed coral limestone is present.

John W. Dwinelle, in an address delivered in San Francisco

PLOUGHING FIELD BEFORE PLANTING CANE, PHILIPPINES

PLOUGHING AT LA CARLOTA, OCCIDENTAL NEGROS, PHILIPPINES

in 1866, said: "Previous to the discovery of America by Columbus in 1492, the Portuguese had discovered the Azore islands in longitude 31 W., and on the strength of that discovery claimed that the countries discovered by Columbus belonged to the crown of Portugal, and that the Spaniards should be wholly excluded from them. But the Spaniards refused to admit this pretension and referred the matter for decision to the Pope, Alexander VI. It was then part of the law of nations, and of the public law of the world, that the Pope was the ultimate source of all temporal power; that he could make and unmake kings, and dispose of all the kingdoms of the earth—powers which he frequently exercised and against which it were vain to contend. He was therefore, by general consent, the acknowledged source of all lawful title to land. He assumed to decide the case thus referred to his decision, and on May 3d, A. D. 1493, determined the matter in dispute between the crowns of Portugal and Spain, by drawing an imaginary line of longitude one hundred leagues west of the Azores, and granting to the Spanish monarchs all countries inhabited by infidels, which they had already discovered, or might afterwards discover, lying to the west, and to the crown of Portugal all those lying to the east of that line. This line was afterwards removed two hundred and seventy leagues further to the west, by a treaty subsequently made in the year 1494, between the kings of Portugal and Spain; but so thoroughly was the title thus conceded by the Pope respected by the civilized world, that when Henry VII of England was afterwards about to intrude upon some of the dominions thus granted to Spain, he abandoned his project upon being warned by the Pope to desist."

This division of the surface of the globe into two parts gave to Portugal all the territory both known and unknown east of the arbitrary meridian drawn 470 miles west of the Cape Verde islands, and to Spain everything west of this line.

Ferdinand Magellan, the famous Portuguese navigator, in the service of the Emperor Charles V of Spain, set out on a voyage west-bound with the object of taking possession of the Moluccas, as they lay west of the line of demarcation. Sailing around Cape Horn, Magellan discovered the Philippine islands in 1521, landing first on Malhou, between Samar and Dinagat. Afterward, he touched at Mindanao, from which he sailed to Cebú. Thence he went to the small island of Mactan, where he was killed in a skirmish.

But little action was taken with regard to this territory until after the accession of Philip II (hence "las Filipinas"—Philippines), when an important expedition was fitted out at the Mexican port of Navidad. It sailed in November, 1564, under the command of Miguél Lopez de Legaspi, the distinguished conquistador, who, in the following year established on the island of Cebú the first permanent settlement in the Philippines. The city of Manila was founded in 1571 and became the capital of the group. Through his tact, courage and resourcefulness, Legaspi won the confidence of the people and placed the colony on a sound footing. At the same time he checked all attempts at encroachment on the part of the Portuguese. Spanish rule was undisturbed until 1762, when a British naval force bombarded Manila and occupied it. At the conclusion of the war between Great Britain and Spain in 1764, the British withdrew and the domination of Spain endured until 1898, when the Spanish fleet was destroyed by Dewey at Manila bay.

The title to the Philippines therefore passed through the Pope to Spain and from Spain to the United States.

When Magellan reached these islands he found that sugar was made in a primitive fashion. The methods employed were very much like those in vogue in China, and the sugar, when made, greatly resembled the Chinese product. This is very strong presumptive evidence that cane and the knowledge of its

HAULING CANE, PHILIPPINES

CARABAO MILL, PHILIPPINES

manufacture were originally brought to the Philippines by the Chinese.

The industry, however, amounted to very little prior to 1849, in which year the island of Negros was placed under the jurisdiction of the religious order of Recoletos, who did much to encourage the manufacture of sugar, and this movement was stimulated by the high prices resulting from the Crimean war. In consequence, cane sugar was exported with profit from Negros, Luzon and Cebú. Notwithstanding the lack of capital, the rough, crude mills, the planters' scant knowledge of manufacturing methods and the wretched transportation facilities, the sugar trade forged rapidly ahead until in 1893 the exports totaled 257,550 long tons. A slump in the price of silver, however, brought on a financial crisis, and subsequently internal dissensions affected the crops so that in 1901 only 51,448 tons were exported. Since then a change for the better has taken place and the figures for 1915-16 indicate a production of 345,000 tons.

Sugar cane is used as a delicacy in all of the inhabited islands of the Philippine group, but the growing and manufacture of it as a regular industry are confined to Negros, Mindoro, Cebú, Panay, Luzon and Leyte. In 1914-15 about 350,000 acres altogether were planted in cane, and the quantity of sugar exported during 1916 was about 300,000 tons.

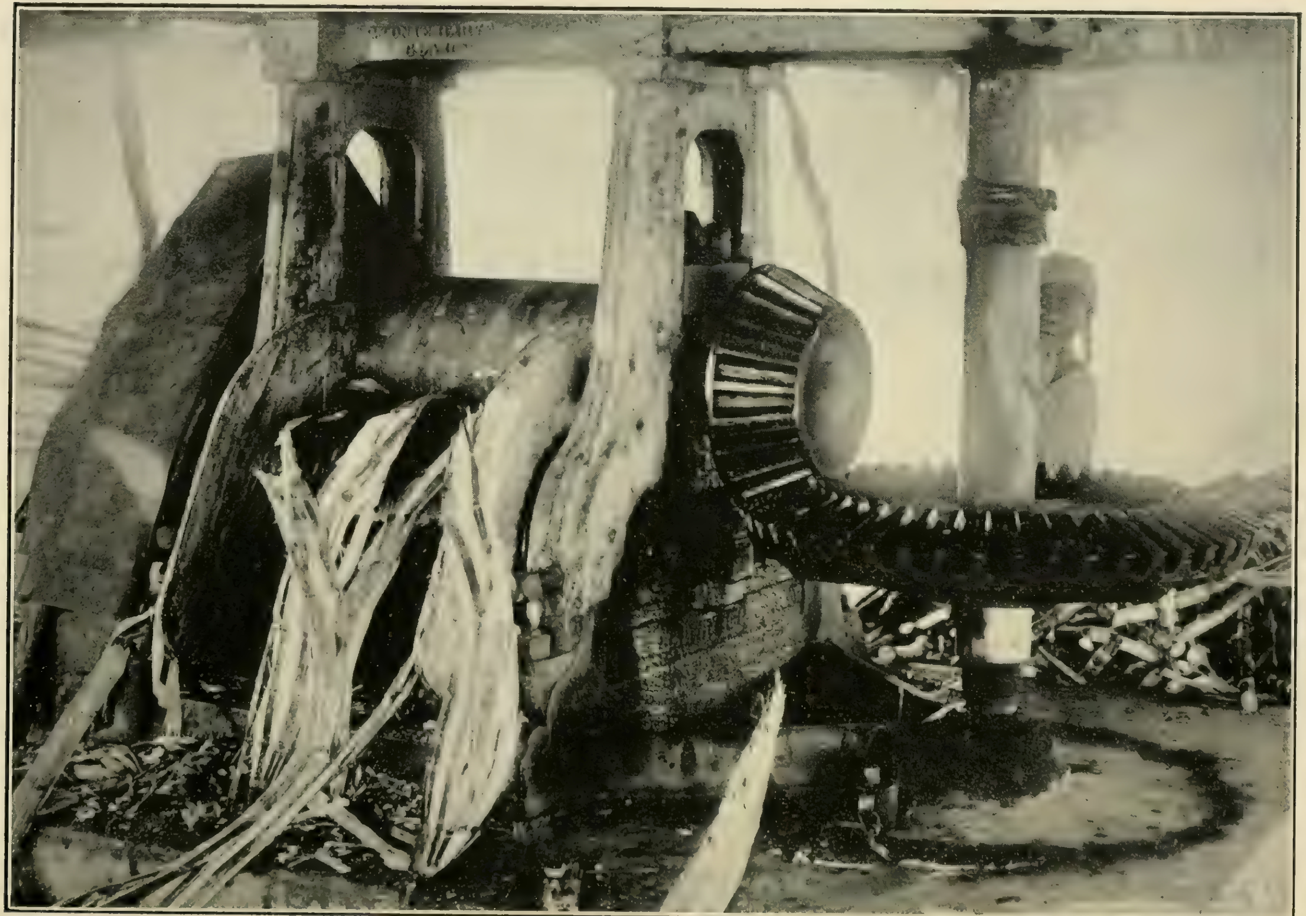
The first care of the United States after its occupancy of the Philippines was the bettering of conditions in sanitation, education, banking methods, railway communication and deep water terminals. Apart from the primitive character of the sugar mills and the loss growing out of poor extraction of juice, open-kettle boiling and curing in earthen pots, the sugar producer was generally in debt to the buyer for advances that carried a high rate of interest. The government has taken steps to correct this evil and has made it possible for the farmer to get credit on reason-

able terms, limiting its loans, however, to those who have Torrens titles to their property,[1] but the Filipino has been under the influence of the money-lenders too long for him to break his bonds entirely. Besides, his instinctive dislike for anything new is a hindrance to progress in this direction.

In addition to the measures just alluded to, a special law was passed in 1902, under which all Philippine sugars entering the United States paid 25 per cent less than the regular customs tariff. The Payne-Aldrich bill of August 5, 1909, provided for free admission of Philippine sugars up to 300,000 gross tons, and it stipulated that the small producer (less than 500 tons per annum) was to receive first consideration in the event of the importation exceeding 300,000 tons. Any excess coming into the United States would have been assessed the full tariff. During the life of this legislation, however, the largest production of the islands was that of 1913-14, which amounted to 265,000 tons, of which 225,000 tons were exported.[2] The tariff act of 1913, which became effective March 1, 1914, admits all Philippine sugars free of duty without any restriction as to quantity.

The religious orders were formerly large land owners in the Philippines, and the feeling of discontent that ultimately led to the insurrection of the Filipinos against Spain in 1896 was largely due to agrarian difficulties between the friars and their tenants. When the revolution came, the friars had to flee for their lives, and after peace was restored by the United States, the insular government felt that if they returned to their possessions they would be in constant danger from the hostility of the natives. It was, therefore, decided to acquire these lands and to that end Congress passed an act authorizing the Philip-

[1] A survey under the Cadastral survey act, passed by the Philippine legislature in 1913, *i. e.*, a survey of the land and assessment of its value as a basis for taxation would support a Torrens title. [2] Harold M. Pitt in his treatise, *Reciprocity and the Philippine Islands*, Manila, 1911, says that it is estimated that from 40,000 to 50,000 tons of sugar are consumed in the islands.



OLD-STYLE SUGAR MILL, PHILIPPINES—SHOWING POOR CRUSHING

TINGUIAN CANE CRUSHER, LINGAYEN, PHILIPPINES

pine government to issue bonds to the amount of $7,000,000 and to purchase the lands of the various orders with the money so raised. With one or two minor exceptions, all of these lands, amounting to something over 600,000 acres, were bought by the government and are being resold on long-term payments at a price that will reimburse the government. In disposing of this property preference is always given to the resident tenants.

A measure was carried through the Philippine legislature approving the sale of the unoccupied portions of these friar estates to individuals without restriction as to acreage, and it was under the provisions of this act that large tracts of land were acquired by the interests connected with the Mindoro company in the San José estate in Mindoro and by the people associated with the Calamba estate in the Calamba, Santa Rosa and Biñan districts of Laguna province, Luzon.

Apart from these so-called friar lands, the public lands in the Philippine islands are held for sale or lease subject to the following conditions: Corporations can purchase or lease up to 1024 hectares, or 2500 acres, and individuals up to 64 hectares, or 158 acres. The terms of sale are a minimum of 10 pesos, or $5 per hectare, 25 per cent of which must be paid at the time the contract is entered into and the remainder within five years, with interest at 6 per cent, or leased at a minimum rental of 50 centavos, or 25 cents, per hectare per annum, leases running for fifty years.

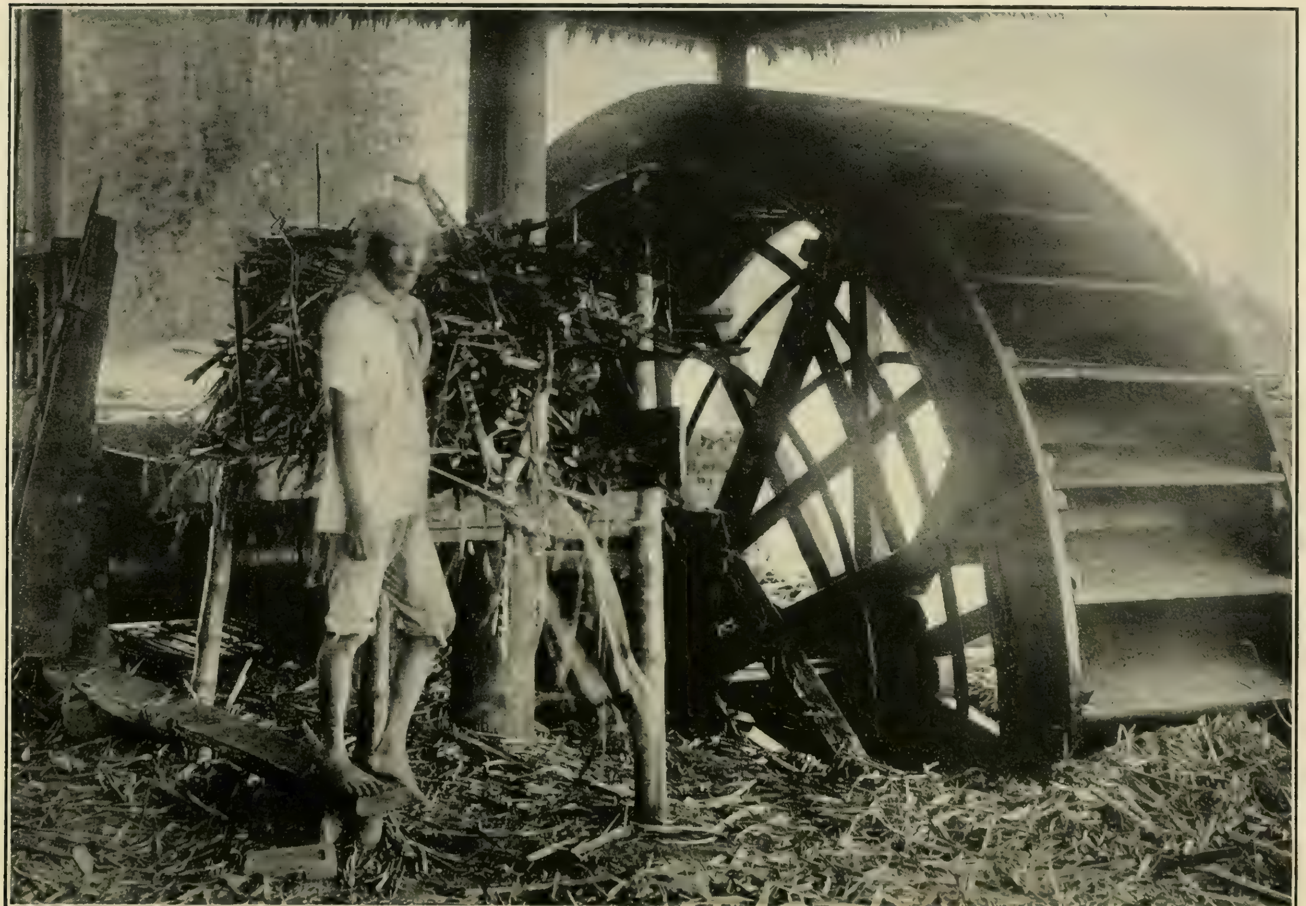
The Mindoro and Calamba companies, controlling 55,000 and 20,000 acres respectively, and the San Cárlos Milling company of San Cárlos, Negros, have erected the first and only modern sugar mills in the Philippines, and they have gone into cane cultivation and sugar manufacture in a scientific way. The management of these three enterprises has been entrusted to men who have had thorough field and factory experience in Hawaii.

Unlike the other two large companies, the San Cárlos Milling

company operates a *central* pure and simple. The company owns no land except the site for the mill and the outbuildings connected with it. It has, however, acquired leases of a certain amount of railway trackage. The capacity of the mill is 1000 tons of cane per day, which means about 125 tons of centrifugal sugar. It was completed at the end of 1913 at a cost of about one million dollars, and the first cane ground was from the 1914 crop.

In the Philippines cane is not planted every year. Herbert S. Walker, in his work "The Sugar Industry in the Island of Negros" (Manila, 1910), says: "A decidedly large proportion of the total land under cultivation in Negros is not replanted every year, but is allowed to ratoon, from two to eight crops being taken off without replanting. This is especially true in the rich soils of the districts around Ilog-Cabancalan, Binalbagan-Isabela, San Cárlos and Bais. Theoretically, cane planted in some of these alluvial soils, which are flooded and fertilized each year by silt brought down from the mountains by the overflow of a river, might go on ratooning indefinitely. Practically, the period between plantings is limited strictly by financial considerations.

"Much time and expense are saved by not being obliged to replant. On the other hand, the yield from plant cane is, as a rule, greater than even from first ratoons, and with each successive ratoon crop the total amount of sugar produced per hectare of land is decidedly diminished. This is partially due to the shorter time in which the cane is allowed to ripen. Owing to excessive rains prevalent in this country, canes must be cut every year, and the practice so common in Hawaii of allowing ratoons to ripen for eighteen months or more, is here out of the question. A further obstacle, especially when canes are planted closely in rows, is the tendency of ratoons to spread out in every direction from the original plant so that in the course of a few years the



OLD WATER-DRIVEN MILL, ISLAND OF NEGROS, PHILIPPINES

MILL DRIVEN BY WATER POWER, OCCIDENTAL NEGROS, PHILIPPINES

cane rows lose all semblance of regularity, and proper tillage of the soil is rendered very difficult; thus many young ratoons are stunted in their growth by weeds."

The time of planting in most parts of the islands is usually from December until April, but in Negros, where the soil is good and the rainfall well distributed, planting can be done at almost any time, except during the period of very heavy rains, *i.e.,* from July to October.

The yield of sugar per acre may be approximated as follows:

| | |
|---|---|
| Plant cane | 2.5 tons |
| First ratoons | 2.0 " |
| Second ratoons | 1.75 " |
| Third ratoons | 1.50 " |
| Fourth ratoons | 1.25 " |

When the yield drops as low as eight-tenths of a ton of sugar per acre, replanting is necessary, and allowing for the reduced yield of first and second ratoons, it may be reckoned that one-half of the production is from plant cane and the other half from ratoon crops.

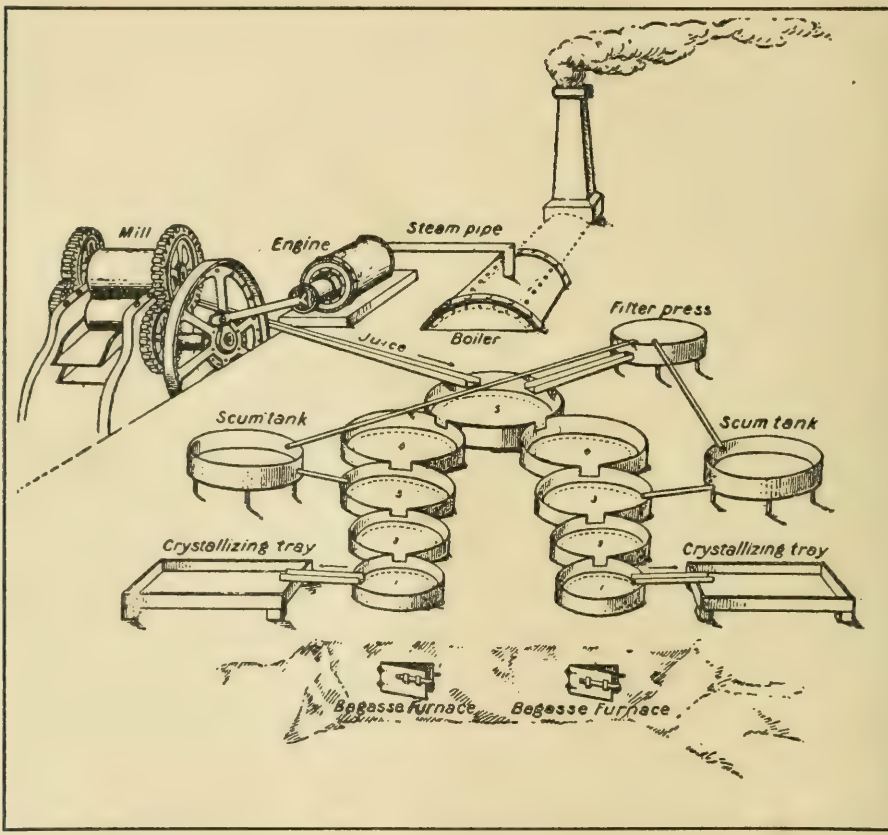
The length of time during which the cane is allowed to remain in the ground varies from nine to fourteen months and will probably average between eleven and twelve.[1]

The labor problem is present in the Philippines as in all cane-sugar countries. The natives are willing enough to work, but shrink at the idea of leaving their homes to take employment at any considerable distance away.

Apart from the three modern factories previously mentioned, sugar-making facilities are greatly behind the times, although there are a few minor exceptions. Over one thousand small mills were in operation in the islands in 1907 and of these 528 were driven by steam, 470 by carabao (water oxen) or natives,

[1] Walker, H. S. *The Sugar Industry in the Island of Negros.* Manila, 1910.

and 77 by water power. The carabao mills, however, are rapidly disappearing. The capacity of most of these small mills is from 50 to 60 tons of cane per day, and, as the cane is only crushed once, there is a considerable loss in recovery. A little lime is added to the juice to clarify it and it is then boiled to grain in




a series of five or six open pans. The general arrangement is shown by the accompanying sketch, which is taken from Herbert S. Walker's "Sugar Industry in the Island of Negros."

The drawing shows two sets of pans, each set being built over a separate furnace. The number 5 pan, into which the juice

NATIVE SUGAR FACTORY, PAMPANGA PROVINCE, PHILIPPINES

INTERIOR OF CAMARIN, PHILIPPINES

from the crusher flows, is connected to both sets. The furnaces are fed directly under number 1 pan, where the final boiling is done and where the greatest heat is required. The two furnaces converge when they reach the boiler, which may be fired separately, so that grinding and boiling may, if necessary, be done independently of each other. As the juice leaves the crusher through an open wooden trough, particles of cane and other matter are removed by straining through a cloth or a close-meshed wire screen. It runs into the receiving pan—number 5—and is heated to between 160 and 175 degrees Fahrenheit, which brings certain impurities to the surface in the form of froth. This is skimmed off and thrown into the scum tank; the juice is then ladled by hand as required into the smaller pans (number 4) where lime is added for clarification. Violent agitation takes place in pans numbers 3 and 2, and as fast as scum forms it is skimmed off. The clarified juices are then concentrated in pans number 2 and number 1, after which the massecuite is put into wooden trays and stirred with a spade until it granulates. It is then ready to be taken to market.

As has been pointed out, the loss in this primitive method of manufacture is very heavy. Notwithstanding the fact that all of the molasses is retained in the sugar, the amount of sucrose that is lost or wasted is 44 per cent, and over one-half of this is left in the bagasse.

Apart from centrifugals, Philippine sugars consist of the following grades: *Superior, Humedo* (wet) and *Corriente* (current). Sugars polarizing from 87 to 88.9 degrees are called Superior No. 1, those testing from 85 to 86.9 degrees, Superior No. 2, and those running from 80 to 84.9 degrees, Superior No. 3. Humedo sugars polarize from 76 to 79.9 degrees and Corriente from 70 to 75.9 degrees. Roughly speaking, the proportions are about 85 per cent of Superior of 84 degrees purity and 15 per cent of wet sugar testing somewhere near 75 degrees.

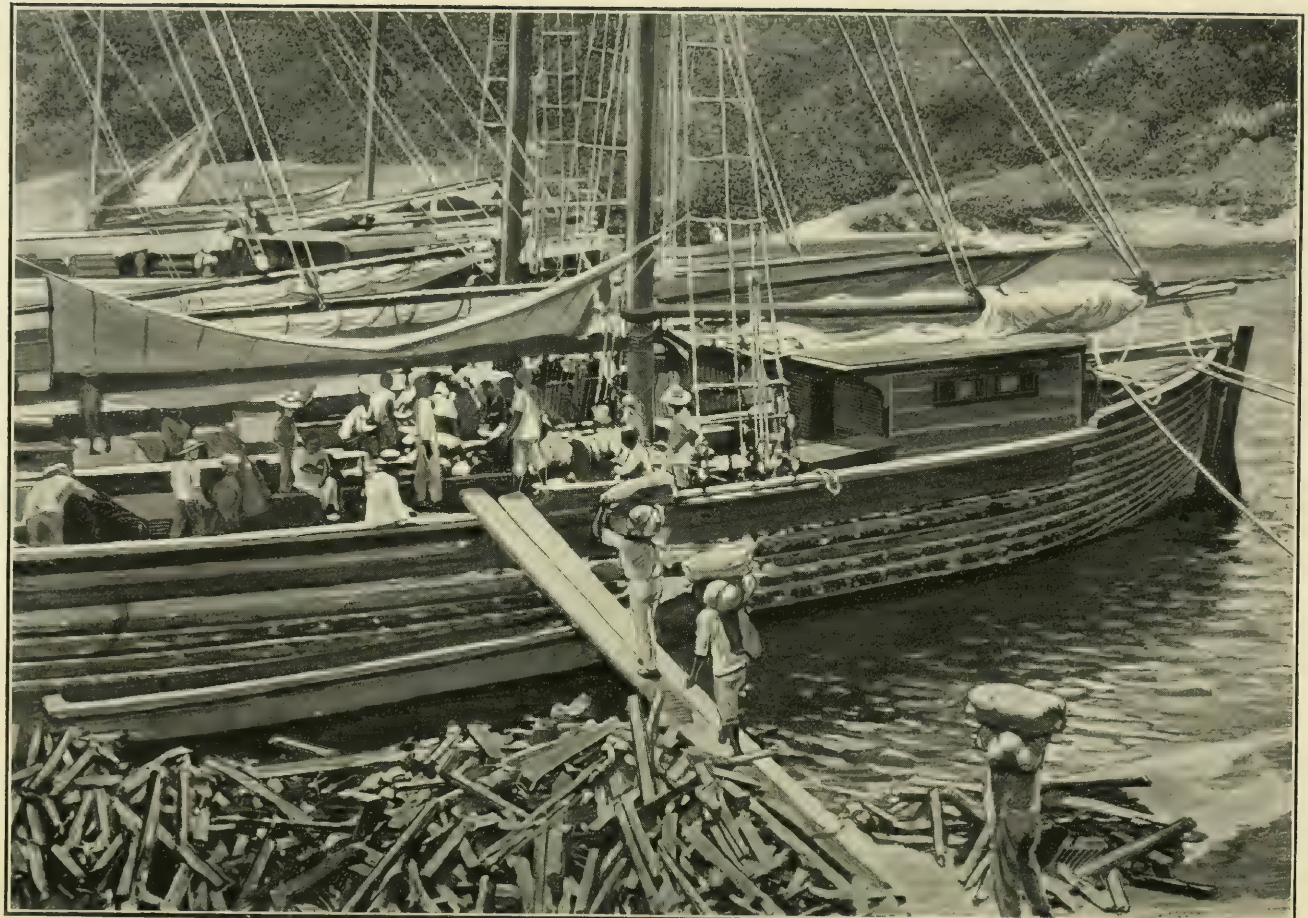
The Bureau of Agriculture of the Philippines maintains experiment stations at La Granja, near La Carlota, Occidental Negros, and at Calamba, Luzon, for the study of cane, soil analysis and the solving of fertilization problems. This work of scientific investigation is sure to be of great benefit to the industry. Some experimental work with sugar cane is also carried on at the station at Alabang, Laguna province, Luzon.

American control in the Philippines promises much for the future of the sugar industry of these islands, for when it is remembered that for many years, in spite of the handicap of crude, uneconomic methods, export duties at home and import duties abroad, sugar was made and sold at a profit in the markets of the world, it is not unreasonable to look for a considerable stimulus to be given to production by advanced scientific management and free admission of the commodity to the markets of the United States.

Quantity of sugar exported from the Philippine islands from 1895 to 1916, in tons of 2240 pounds:

| | | | |
|---|---|---|---|
| 1895 | 227,279 | 1906 | 122,417 |
| 1896 | 226,279 | 1907 | 120,050 |
| 1897 | 198,899 | 1908 | 140,197 |
| 1898 | 177,962 | 1909 | 125,276 |
| 1899 | 91,583 | 1910 | 114,506 |
| 1900 | 61,752 | 1911 | 203,394 |
| 1901 | 51,448 | 1912 | 190,702 |
| 1902 | 90,617 | 1913 | 155,201 |
| 1903 | 88,144 | 1914 | 232,761 |
| 1904 | 82,656 | 1915 | 207,679 |
| 1905 | 103,334 | 1916 | 300,000 |

LUZON SUGAR REFINERY, MALABON, RIZAL, PHILIPPINES



LOADING SUGAR ON LORCHAS, PHILIPPINES

# CUBA

THE island of Cuba lies between 74 degrees and 85 degrees west longitude and 19 degrees 40 minutes and 23 degrees 33 minutes north latitude; its length is about 730 miles, running nearly east and west, and its width varies from 25 to 100 miles. In area it comprises about 45,883 square miles, or 29,365,120 acres, which is approximately that of Pennsylvania or Louisiana. Habana, the capital, is almost on the same parallel as Honolulu and the City of Mexico.

With the exception of a strip of the central-southern coast, Cuba rises boldly out of the sea and presents a rugged appearance to the eye on approach. About one-quarter of its surface is mountainous; three-fifths consists of gently sloping country, valleys and rolling plains; the rest is swampy.

A variety of topographic and climatic characteristics divides the island naturally into three distinct parts. The eastern end is high and broken, with tall commanding peaks; the wide central region, lying well above sea-level, is made up of excellently drained, undulating plains, interrupted at intervals by low, wooded hills; the western portion is a picturesque country of mountain and valley, but of lower altitude than the eastern end. The entire island is covered with a mantle of luxuriant verdure, kept always green by warm mists and generous rains.

A coral reef extends around the greater part of the coast, but between the forbidding rocks and the marshes there are a number of good harbors, chiefest among which is that of Habana, one of the finest in the world. The distance from Cuba to Key West, Florida, is one hundred miles. The census of 1908 placed the population at 2,048,890.

The prevailing winds are the northeast trades, but these are interrupted at frequent intervals by variable winds from other directions which bring changes in temperature and rainfall. Compared with those of Hawaii, the mountains are low, usually not over 2000 feet, and do not produce the effect of a wet side and a dry side to the island, as the trades sweep it from end to end and not transversely. To give an idea of climatic conditions, the average maximum temperature in Habana in 1914 was 90 degrees Fahrenheit, the minimum 53 degrees and the mean average 77 degrees. The total rainfall was 46.15 inches. Seventy-five per cent of the rain occurs in the summer months, between the first of May and the first of October, and the precipitation is greater in the eastern part of the island than in the western. The winters are comparatively dry. This combination of dry winters and wet summers is extremely favorable to the growing and harvesting of sugar cane.

The low plains along the coast are of coral formation and the soil overlying the coral is often found to be shallow. The richest and most productive soil is that of the uplands some distance from the sea. In Cuba the soils may be said to consist of two kinds—the red and the black. The red is generally of great depth, from 30 to 50 feet, and rests on a stratum of free limestone. The black soil, varying in color from a mulatto to a "gumbo" black, overlies a clay formation, and as a general rule is not so deep as the red soil. Owing to the fact that the black soil retains such a large percentage of water during the extremely rainy period, the cost of cultivation is double that of working the red soil.

The date of the introduction of sugar into Cuba is uncertain. Different authorities place it anywhere from shortly after the discovery of the island in 1492 to 1580. Von Humboldt is silent on the point, but says that Cuba did not participate in the sugar industry to any extent in the sixteenth century, so that its im-

*American Photo Co., Habana.*

CENTRAL FACTORY, GENERAL VIEW, CUBA

*American Photo Co., Habana.*

CUBAN CENTRAL—GENERAL VIEW

portance in that respect belongs to a later period.[1] Up to 1772 sugar cultivation was greatly hampered by restrictions of the Spanish government; after that date special privileges were canceled and the right to grow sugar was given to all Spaniards. This naturally encouraged production, which from 4390 tons in 1760 increased to 14,000 tons in 1790. The revolution which destroyed the sugar plantations and mills of Santo Domingo in 1791 stimulated the development in Cuba still further. During the ten years that followed, the number of mills increased from 473 to 870, and by 1802 the output of sugar reached 40,800 tons. In those days mills were very small, crude affairs and were worked by oxen.

Cuba, in common with all sugar-raising countries, felt the effects of the European wars very severely, but her sugar trade revived after the overthrow of Napoleon and the resumption of commerce through normal channels.

With increased production the question of labor became a serious one. The number of slaves on the island had been sufficient as long as the sugar crop was limited, but with expansion came the need for more African negroes, so in 1834 the governor, Miguél Tacon, caused many new slaves to be brought in. He did much to help the industry in other directions, particularly by suppressing abuses, and under his ad-

[1] Prescott, in his *Conquest of Mexico,* (Vol. I, pp. 220 *et seq.*), gives the following in connection with the discovery of the new world by Columbus:

"Of the islands, Cuba was the second discovered; but no attempt had been made to plant a colony there during the life of Columbus, who, indeed, after skirting the whole extent of its southern coast, died in the conviction that it was part of the continent. At length, in 1511, Diego, the son and successor of the 'Admiral,' who still maintained the seat of government in Hispaniola, finding the mines much exhausted there, proposed to occupy the neighboring island of Cuba, or Fernandina, as it was called in compliment to the Spanish monarch. He prepared a small force for the conquest, which he placed under the command of Don Diego Velasquez. The conquest was effected without much bloodshed. After the conquest, Velasquez, now appointed governor, diligently occupied himself with measures for promoting the prosperity of the island. He formed a number of settlements and invited settlers by liberal grants of land and slaves. He encouraged them to cultivate the soil and gave particular attention to the sugar cane."

ministration the planters enjoyed prosperity such as had never been known. Fresh lands were brought under cultivation and the shipping ports grew in importance and activity.

While figures showing the annual production of Cuba were tabulated, beginning with 1850, their accuracy was open to question until 1882, in which year an export duty was imposed, and the records kept by the authorities from that time forward are reasonably correct. Nevertheless, it is known beyond any doubt that 610,000 tons were produced in 1870 from 1200 small mills.

The first war with Spain (1868-78) and the abolition of slavery worked havoc with the industry. All children born of slaves were proclaimed free in 1872 and slavery was entirely abolished in 1880, without any indemnification to the slave owners. Sugar producers found freeman labor both costly and hard to obtain, the island was ravaged by fire and sword, and in the markets of the world beet-root sugar, protected by bounties, was proving a powerful competitor. These were dark days for the planter.

With the restoration of peace, conditions improved. By 1890, 470 mills were in operation and their production in that year was 625,000 tons. In Cuba a change in methods came about, just as had been the case in Louisiana; the cultivation of sugar was gradually dissociated from its manufacture, and as mills became fewer in number, plantings increased. The manufacturers leased tracts of land to farmers, from whom they bought the cane raised on it. Independent planters, too, sold their cane to the central mills, and the plan was adopted so generally throughout the island that but little cane was grown by the owners of the centrals. During this period of peace and development, the tonnage mounted steadily upward and in 1894 it totaled 1,054,214 tons.

The following year saw the renewal of hostilities with Spain,

*American Photo Co., Habana.*

CANE FIELD, CUBA

*American Photo Co., Habana.*

LOADING CANE ON OX-CARTS, CUBA

which dragged along with brutality and devastation until May, 1898, when the United States declared war against Spain and finally established the Cuban republic. The period of this second rebellion against Spain was marked by ruthless destruction of property, the burning of mills and cane in the fields, and the killing of the cattle that were used for transport purposes. In 1897 the output of sugar had shrunk to 212,051 tons. The work of reconstruction after the expulsion of the Spaniards was slow, involving as it did a tremendous amount of effort and the investment of a great deal of new capital. Manufacturers who were unable to raise money to rebuild or re-equip their mills turned planters and grew cane for the nearest centrals. Some, more fortunate, succeeded in securing the money they needed and restored and extended their property. Far the greatest number, however, being unable to command the ready cash for immediately necessary repairs, incorporated or sold their holdings outright to newcomers. The many small, old-fashioned mills have given way to a limited number of large plants, or centrals, that are under corporate ownership and governed by scientific business principles. This process of consolidating several small factories into one big one is constantly going on, and in addition American capital and enterprise are opening up new lands to cultivation in many parts of the island. To a great extent the old-time planter has had to make room for the corporation, with its powerful resources and modern methods, and while the individual has suffered in many instances, the industry has greatly benefited.

Cuban plantations may be divided into two classes, the ingenios and the centrals. The ingenio is a small plantation whose lands lie in the neighborhood of the mill, while the central, in addition to its own cane, handles the crops of a number of ingenios. The ingenio hauls all of its cane to the factory by oxcarts; the central is served by railroads, both privately and

publicly owned, and its equipment and machinery are of the most modern type.

Approximately 90 per cent of the cane grown in Cuba comes from what are termed *colonias, i.e.,* farms varying in size from a few acres up to several hundred.

*Colonos,* or farmers, may be classified in three groups: in the first is the man with his small *estancia,* or farm, on which he raises foodstuffs and cattle, and who takes his few hundred *arrobas*[1] of cane to the central when the price is good, or feeds it to his animals when the pasturage is short. In this class, too, is the man who has a hundred or two hundred *caballerías*[2] of land, but whose chief interests are in other channels and whose operations in cane growing are merely an adjunct to his regular business.

In the second group is the independent farmer, who owns his land and cane and sells his crop to whom he pleases.

The third and most numerous group comprises those who plant cane on lands belonging to the central. These people either pay rent, or receive a certain fixed amount for their cane, or both. Their work is at all times subject to inspection by the central administration and under such circumstances they may be likened to contractors or employés, whose compensation is based upon the success of their own efforts.

The average size of a colonia, exclusive of those owned by colonos of the first-mentioned class, who are independent of cane growing, doubtless depends upon what would afford a man a decent living with a few luxuries. H. C. Prinsen Geerligs, in his book "The World's Cane Sugar Industry," states that one hundred arrobas (2500 pounds) of cane costs the Cuban farmer $2.07 at the mill. If 2½ cents be taken as an average price for sugar and $900 per annum as a fair living wage, then the colono who gets an average yield of 50,000

[1] 25.317 lbs.=1 *arroba.* [2] A *caballería* is generally taken to mean 33⅓ acres.

arrobas per caballería and is paid for it at the rate of 5 per cent, receives $1560 per caballería for cane that has cost him $1035 to produce. According to this reasoning, a colonia should not be less than 1.75 caballerías in size, but of course this is purely speculative.

The farmer who owns his land is paid about six per cent[1] of the weight of the cane he furnishes in centrifugal sugar of 96 degrees, sacked and ready for shipment, and occasionally delivered at the nearest shipping port. Sometimes settlement is made in cash, based upon the value of the agreed percentage of sugar at the Habana quotation on the day the cane is delivered. In other words, for every one hundred pounds of clean cane in bundles, delivered on board the cars, the plantation pays the grower about six per cent of 96-degree centrifugal sugar, or its equivalent in money.[2]

Where the land is furnished by the plantation, the farmer is paid from four to five per cent of the weight of the cane in sugar. He is given a house free of rent and an acre or two of garden land as well. All material, labor or stores supplied to him are debited to him to be accounted for when final settlement is effected.

Planting cane in Cuba is a simple matter. In preparing virgin forest land for seed, no ploughing whatever is done; the trees and shrubs are cut down and allowed to dry, the valuable timber is carried away, and the remainder is burned. When this is done the land is found to be smooth and level, as a rule. Planting consists in making holes in the ground with a heavy pole shod

[1] See Report of E. E. Paxton, Honolulu, T. H., 1905. [2] Extremely high prices are paid only in districts where the number of sugar mills is unusually large and the competition for cane consequently very keen. For example, if a central needed 200,000 tons of cane in order to grind at full capacity during the season, and if its own cane and that which it had already purchased amounted to 175,000 tons, it might pay an excessive price for the remaining 25,000 tons. There is, however, no such thing as uniformity in the contracts made with colonos, except that the price is based on weight and not on sugar content.

with iron that is driven obliquely into the earth at regular intervals, the seed is then dropped in these holes and covered with earth, completing the operation. Grassy ground, however, must be ploughed, in which case furrows are made six feet apart. The seed cane is planted in them at intervals of from six inches to twelve inches, covered with earth and left to grow. There are the spring plantings and the autumn plantings, the first from April to June and the second in October and November, that is to say, one at the beginning and one at the end of the rainy season. In the case of the former, if the rains come soon after planting, the cane can be cut in the following March or April, *i. e.,* after a growing period from nine to twelve months. If, however, the rains are late the cane cannot mature before the advent of the new rains and therefore cannot be ground until the following December. Cane planted in the fall ripens in December of the next year or sometimes a month later.[1]

Notwithstanding the little care given to the planting, the cane once started yields a generous crop, which is followed by profitable ratoon crops for a number of years without fertilization or a great amount of tillage. Finally, when through age the cane ceases to produce a paying crop of ratoons, the old roots are taken up,[2] and the same soil reseeded brings forth excellent results for another period of years without any rotation of crops being necessary. Not more than ten per cent[3] of the total area of Cuba is devoted to the growing of cane. In addition to the ground on which cane is actually planted, large tracts are needed as pasture for draft cattle. Besides, there is

1 A well-known authority on sugar culture states that ratoons constitute about 90 per cent of the Cuban crop, and that it takes twelve months for ratoons to ripen. *Primavera,* or cane planted in the spring, is cut when twelve months old, and *caña fria,* or cane planted in the fall, is cut when it is between fourteen and eighteen months old. The industry has been greatly extended during 1915 and 1916, and consequently much new planting has been done. These plantings will be ratooned after the first crop is taken off.

2 Geerligs, p. 177.

3 On December 16, 1914, Willett & Gray gave the average as between 2,250,000 and 2,500,000, to which the recent new plantings must be added.

*American Photo Co., Habana.*

TRAIN-LOAD OF SUGAR CANE, CUBA

American Photo Co., Habana.

SELF-DUMPING CANE CAR, CUBA

much forest land and many barren spaces that are undoubtedly included in the acreage classified as being under cane cultivation. According to Dr. W. D. Horne,[1] the average yield is from fifteen to twenty tons of cane per acre[2] and the crops are usually allowed to ratoon for ten years.

In Cuba, cane diseases are of rare occurrence, but in dry years swarms of mice invade the fields and cause great damage by gnawing the cane. They rapidly disappear, however, as soon as the wet season sets in. It is the weather that brings success or failure to the sugar crop, for the growth of the cane is entirely dependent upon rainfall and a long period of drought is extremely hurtful. Hurricanes that sweep in from the Caribbean sea work havoc in the plantations, beating the cane flat to the ground or uprooting it altogether, which results in heavy damage both to the growing crop and the one following it.

Harvesting is generally begun in December and over in May, although one or two centrals continue in operation practically all the year round. Weather conditions determine when the grinding starts and ends, for, as a rule, the cane has to be hauled from the fields to the weighing station in huge carts drawn by oxen. When the roads are dry, three pairs of oxen can pull a load of 7500 pounds of cane with ease, but as soon as the heavy rains set in the ground quickly softens, the roads become impassable and the movement of cane by carts is out of the question.

The cane is cut close to the ground with a long, heavy knife, called a *machete*. It is "topped," cut into two- or three-foot lengths, tied in bundles and loaded on the ox carts to be hauled to the scales and thence by rail to the mill. The stumps that remain in the ground are covered over with dry leaves to con-

[1] Journal, Society of Chemical Industry, Vol. XXV, pp. 161 *et seq.* [2] Prinsen Geerligs says that the average yield is 50,000 arrobas per caballería, or 16.82 long tons per acre, but that a good crop gives 80,000 arrobas (26.92 long tons per acre) and sometimes 100,000 arrobas per caballería (33.65 long tons per acre) or even more are obtained.

serve the moisture in them. Nourished by occasional showers, the roots quickly sprout and a year afterward a crop of ratoons is ripe and ready to be harvested.

Wages in Cuba are higher than in most important cane-producing countries in the tropics, and Dr. V. S. Clark quotes a number of authorities to show that inefficiency makes Cuban labor costs in most lines of work relatively higher than in the United States and other countries on the American continent, although he says that American supervision has in some instances increased efficiency greatly.[1] (Bureau of Labor, Bull. [L. of C.] 41, pp. 712, 778.)

Complete, reliable and up-to-date information and statistics concerning Cuba's sugar industry are not obtainable at the moment, nevertheless it is well known that the Cuban plantations and mills that are operated by modern scientific methods can produce sugar at lower costs than Germany or any of the beet-raising countries, while as regards cane-growing countries, Java is the only possible rival. And yet, despite the optimistic views of Cuba's supporters, the fact remains that the full development of her resources is still a matter of uncertainty, though the possibilities for expansion are enormous, provided that certain obstacles, notably the labor problem, can be overcome. At the present time it is doubtful whether the production of sugar could be largely increased, chiefly because of the growing difficulty of securing adequate help in the fields.

During the season ending midsummer, 1915, Cuba's output of sugar was 2,592,667 long tons, the largest crop raised in any country in the world, and the vast amount of cane from which it was manufactured was ground by 176 central factories. It is estimated that the production for 1916 will reach 3,000,000 tons.

[1] *The United States Beet Sugar Industry and the Tariff.* Blakey, p. 179.

When it comes to the marketing of her sugar the United States is Cuba's best customer, only a comparatively small amount being taken by Europe.[1] The 20-per-cent preferential allowed on Cuban sugar duty under the reciprocity treaty, however, does not always go to the Cuban manufacturer. The real beneficiary is the consumer in the United States, for this reason: when the grinding of the Cuban crop is in full swing, the weekly production of raw sugar is approximately 150,000 tons, which speedily exhausts the available storage capacity of the island, so that movement of the sugar is imperative; besides this, the natural anxiety of the planter to realize in order to meet his current expenses causes a strong pressure to sell. It becomes with him a question of whether he can net better figures in New York or the United Kingdom, and owing to difference in port charges and dispatch, the New York results are generally more satisfactory, even with the concession of a part, or at times all of, or even more than, the 20-per-cent preferential. Inversely, it follows that when raw sugars are in keen demand, the planter pursues his advantage to the limit.

The total production of sugar in Cuba from 1850 to the present year is as follows, but the figures prior to 1882 are not entirely dependable, as has been previously explained:

| YEAR | TONS | YEAR | TONS |
|---|---|---|---|
| 1850 | 223,145 | 1857 | 355,000 |
| 1851 | 263,999 | 1858 | 385,000 |
| 1852 | 251,609 | 1859 | 536,000 |
| 1853 | 322,000 | 1860 | 447,000 |
| 1854 | 374,000 | 1861 | 446,000 |
| 1855 | 392,000 | 1862 | 525,000 |
| 1856 | 348,000 | 1863 | 507,000 |

[1] This is not true of the years 1915 and 1916, when on account of the war Great Britain, France and other European countries have been compelled to draw large quantities of sugar from Cuba and the United States.

| YEAR | TONS | YEAR | TONS |
|---|---|---|---|
| 1864 | 575,000 | 1890 | 632,368 |
| 1865 | 620,000 | 1891 | 816,980 |
| 1866 | 612,000 | 1892 | 976,000 |
| 1867 | 597,000 | 1893 | 815,894 |
| 1868 | 749,000[1] | 1894 | 1,054,214 |
| 1869 | 726,000[1] | 1895 | 1,004,264 |
| 1870 | 726,000[1] | 1896 | 225,221[3] |
| 1871 | 547,000[1]* | 1897 | 212,051[3] |
| 1872 | 690,000[1] | 1898 | 305,543[3] |
| 1873 | 775,000[1] | 1899 | 335,668 |
| 1874 | 681,000[1] | 1900 | 283,651[4] |
| 1875 | 718,000[1] | 1901 | 612,775 |
| 1876 | 590,000[1] | 1902 | 863,792 |
| 1877 | 520,000[1] | 1903 | 1,003,873 |
| 1878 | 533,000[1] | 1904 | 1,052,273 |
| 1879 | 670,000 | 1905 | 1,183,347 |
| 1880 | 530,000 | 1906 | 1,229,736 |
| 1881 | 493,000 | 1907 | 1,444,310[5] |
| 1882 | 595,000 | 1908 | 969,275[6] |
| 1883 | 460,327[2] | 1909 | 1,521,818 |
| 1884 | 558,932 | 1910 | 1,804,349 |
| 1885 | 631,000 | 1911 | 1,483,451 |
| 1886 | 731,723 | 1912 | 1,895,984 |
| 1887 | 646,578 | 1913 | 2,428,537 |
| 1888 | 656,719 | 1914 | 2,597,732 |
| 1889 | 560,333 | 1915 | 2,592,667 |

1916 3,000,000[7]

*[1] Hurricane. [1] Ten years' war. [2] Internal disturbances. [3] Rebellion against Spain. Spanish-American war. [4] Great drought. [5] Particularly favorable weather. [6] Great drought. [7] Estimated.

# JAMAICA

JAMAICA lies 80 miles south of the eastern end of Cuba, between 17 degrees 43 minutes and 18 degrees 32 minutes north latitude and 76 degrees 10 minutes and 78 degrees 20 minutes west longitude. It is 144 miles long and 50 miles across at its widest part, with a total area of 4207 square miles.

The island is traversed from east to west by a mountain range from which a number of spurs run out to the northwest or southeast. This range is more sharply defined in the eastern end, where the highest point is Blue Mountain Peak, 7360 feet above sea-level. The mountains gradually slope westward down to the hills of the western plateau, which is of limestone formation and comprises two-thirds of the island's surface. As a rule the highlands terminate abruptly in steep bluffs, a strip of level land lying between them and the sea. On the south coast there are extensive plains. Fully one hundred rivers and streams empty themselves into the Caribbean, but the greater number of them are not navigable and in flood time they become raging torrents. In 1911 the population, of whom only 2 per cent are white, was estimated at 831,123. It is made up of Maroons, descendants of the slaves of the Spanish; descendants of African negro slaves; a mixture of British and negro; laborers from India; a sprinkling of Chinese, and the white settlers.

On the coast the climate is hot and humid, but at the higher elevations it is mild and delightful. The temperature at Kingston and the low sea-level region generally ranges between 70.7 degrees and 87.8 degrees Fahrenheit. At Cinchona, which is 4907 feet high, it runs from 57.5 degrees to 68.5 degrees. With

rare exceptions, rain falls during every month in the year, and there are two wet seasons, each of about three weeks duration, one in May and one in October. The amount varies considerably; the yearly average for Kingston is 32.6 inches, for Cinchona 105.5 inches and for the entire island 66.3 inches. Hurricanes, which were of frequent occurrence during the early part of last century, have not visited the island so often of late years. Earthquakes take place from time to time, that of 1907 having been particularly violent and destructive.

Transportation facilities are excellent, the roads are good and a railway 180 miles long connects Port Antonio, Kingston and Montego bay.

Jamaica was discovered by Columbus on May 3, 1494, and was called Santiago by him, but this never supplanted the original Indian name Jaymaca, "the island of springs," modified into its present form, Jamaica. Columbus put in at the island for shelter in 1505, and four years later his son Diego sent out Don Juan d'Esquivel to take possession of it in the name of the Spanish crown. Sant' Iago de la Vega, now Spanish Town, founded in 1523, was destroyed by the British in 1596 and was rebuilt after their departure. The British raided the island again in 1635, and twenty years later they occupied it permanently, expelling the Spaniards entirely by 1658. During the three years that followed, Jamaica was under military rule and then a constitution modeled upon that of the mother country was established.

About this time the island became a rendezvous for the buccaneers. These gentry quite often combined the roles of merchants or planters and pirates or sea-rovers. In 1670 the treaty of Madrid confirmed the British in their possession of the island and the buccaneers were suppressed. Jamaica then became a great slave market, and the growing of sugar cane and the manufacture of sugar on an extensive scale were begun.

Civil disturbances retarded the progress of the colony until 1728. The town of Port Royal was destroyed by a great earthquake in 1692, while in 1712 and 1722 hurricanes of extreme violence carried destruction throughout the island.

When the Dutch were driven from Brazil by the Portuguese in 1655 many of them settled in Jamaica, Barbados and other West Indian islands. They brought their slaves with them, and, besides, they had a good knowledge of sugar and the necessary capital, so that the industry entered a new phase of development after their arrival. The keenest competitors of the British islands were the French sugar producers of Saint Dominique, Guadeloupe and Martinique, as they were more skilled in manufacturing methods and made sugar at a lower cost. A heavy export tax affected the sugar trade of Jamaica and her sister colonies adversely. The refining of sugar was prohibited and heavy import duties placed upon sugar and syrup entering British North American possessions closed that market to the Jamaican product. Notwithstanding these drawbacks the industry continued to grow and in 1791 the destruction of the plantations of Saint Dominique removed a formidable rival.

Since the passage of the emancipation act in 1834 and the granting of £16,500,000 as partial indemnity to the planters for the loss of their slaves, there has been persistent agitation by the planters, both in Parliament and outside of it. It became very loud when the protection afforded West Indian sugars as against sugars raised in slave-owning countries was lessened and finally withdrawn. It subsided somewhat with the abolition of slavery in the colonies of other European nations, and it was renewed with added vigor when the competition of bounty-nourished beet-root sugar manufactured on the continent of Europe made itself felt. As has been shown, bounties and cartels enabled the European beet-sugar manufacturers to sell their product in foreign markets below actual cost, while

realizing a handsome profit in the quantity sold for home consumption. Jamaica and the other cane-producing colonies which had no domestic trade to fall back upon found themselves in a grievous plight.

By 1895 matters had reached such a pass that a royal commission was appointed to make a thorough investigation of conditions and report to the home government. The main features of the remedial measures adopted as a result of the work of this body were:

First: The establishing of the farmers as owners of land, that is to say, parcels of land were sold to small farmers, who were assisted by money advances in the cultivation of their crops, with the understanding that they were to grow cane at their own risk and sell it to the mills.

Second: Planters were encouraged to raise crops other than sugar.

Third: Agricultural experiment stations were built and equipped in Barbados, Trinidad and Jamaica with sub-stations in a number of the smaller islands.

Fourth: A direct steamship service to Canada was established. The service between Jamaica and England was improved and regular steamer communication between the islands was provided.

It was stipulated that the cost of building and maintaining the experiment stations was to be borne by the home government until the results obtained justified their being supported by the colonies. In addition, a grant of money was authorized by Parliament to take care of the pressing needs of the planters during the year before the Brussels convention became effective.

With improved steamship facilities between Jamaica and the mother country, the volume of the trade in fresh fruit was greatly increased.

*Photo by H. H. Cousins*

MORELANDS SUGAR MILL, VERE, JAMAICA

THE FLEET, MORELANDS, VERE, JAMAICA

In 1907 the value of the fruit shipments in pounds sterling was as follows:

| | |
|---|---|
| Bananas | £842,689 |
| Citrus fruits | 90,468 |

as against

| | |
|---|---|
| Sugar | 122,328 |
| Rum | 98,923 |

On January 14, 1907, an appalling earthquake occurred. The buildings in Kingston and Port Royal were destroyed or badly damaged and about one thousand people were killed.

In 1906 the area under cultivation in Jamaica was 750,000 acres and of this only 26,000 were devoted to cane. Sugar planting has been in a stagnant condition for years and only a limited number of the estates that still carry on the industry are making money. Many have stopped growing cane entirely and have turned to bananas, cocoanuts, coffee or cattle raising. In certain districts there is plenty of fertile alluvial land, ample water and cheap labor, but proper cultivation is lacking, so that the results are far from what they should be. Planting simply consists of sticking a piece of cane stalk in a hole in the ground and very little ploughing is done, consequently the weeds are never under control. It takes about twelve months for the cane to ripen and the yield per acre varies widely, ranging from ten to forty-five tons. The average may be taken as about twenty tons per acre.

The island boasts of three central factories and eighty-two small mills, only twelve of the latter having vacuum pans. The others make muscavado sugar and rum. In the operation of boiling by no means all of the sugar is extracted, as a pure liquor is needed for the manufacture of good rum and quite a large amount of cane juice is made into rum direct.

In the process of making muscavado sugar in Jamaica, the cane juice after being brought to boiling point in an open kettle

is transferred into a second kettle, where it is treated and the heavy impurities allowed to settle. The clear juice then goes into copper walls, a series of three or more large open copper pans, called teaches. These pans rest above an open fire fed by bagasse, cane trash and wood. After the juice has been boiled to a certain density in the first pan it is transferred to the second and the final concentration takes place in the third or fourth, as the case may be. In some mills the last boiling is done with steam in what is called an Aspinall pan, instead of over an open fire. When the mass becomes sufficiently thick, it is put into large tanks and left to crystallize. Sometimes it is kept in motion during crystallization, but usually no stirring whatever is done. Crystallization completed, the mass is packed in hogsheads with perforated bottoms. These hogsheads are allowed to stand over drainage troughs for two or three weeks so that the molasses may run off. The holes are then plugged up and the sugar is ready to be shipped.

The percentage of sugar, glucose and water in Jamaica muscavados is approximately:

| | | | |
|---|---|---|---|
| No. 1 | Sucrose 88.6 | Glucose 5.30 | Water 3.42 |
| 2 | 86.2 | 4.40 | 3.72 |
| 3 | 83.9 | 5.92 | 4.66 |
| 4 | 83.0 | 6.98 | 3.84 |

Management is slipshod and the extraction is poor. It takes fifteen tons of cane and sometimes more to produce a ton of sugar.

As for the future of the sugar industry in Jamaica, much in the way of improvement could be done by the introduction of systematic management, proper cultivation, adequate fertilization and scientific methods of manufacture. Labor is plentiful and cheap, and it would seem that sugar could be produced

in Jamaica at as low cost as in Cuba. Thus far, however, there have been no signs of a real awakening.

As regards production, the following figures are taken from Willett & Gray:

| | | | |
|---|---|---|---|
| 1903-04 crop | 14,255 tons | 1909-10 exports | 12,000 tons |
| 1904-05 " | 16,000 " | 1910-11 " | 19,960 " |
| 1905-06 " | 18,000 " | 1911-12 " | 21,835 " |
| 1906-07 exports | 13,971 " | 1912-13 " | 8,728 " |
| 1907-08 " | 10,718 " | 1913-14 " | 15,583 " |
| 1908-09 " | 11,453 " | 1914-15 " | 15,063 " |
| | 1915-16 exports | 15,000[1] tons | |

[1] Estimated.

# BARBADOS

BARBADOS, the most easterly of the Windward islands, lies seventy-eight miles east of St. Vincent in 13 degrees 4 minutes north latitude and 59 degrees 37 minutes west longitude. It is twenty-one miles long, fourteen and one-half miles at its greatest breadth and its area is 166 square miles. It is of coral origin and at certain points the coral reefs extend out to sea as far as three miles and are a menace to navigation. The island is low and flat, except in the central and northeastern part. Mount Hillaby, the highest peak, rises 1148 feet above sea-level and from it the land slopes in terraces in every direction. Carlisle bay on the southwest is a natural harbor, but only available for vessels of light draft. Barbados is densely populated. In 1906 the number of inhabitants was 196,287, of whom by far the greater number were negroes, who, in proportion to the whites, are as nine to one.

The climate is agreeable, with well-defined wet and dry seasons, and for eight months in the year the heat is modified by the northeast trade winds. The dry, or cold, period is from December to May. The temperature ranges from 70 degrees to 86 degrees Fahrenheit, seldom falling below 65. There is a plentiful rainfall, the annual average being sixty inches, and September is the wettest month. Moisture readily penetrates the coral subsoil and collects in subterranean reservoirs. Porous soil, thorough cultivation and the absence of swamps give miasma no opportunity and fever is unknown, but hurricanes are the scourge of the colony. The soil is thin, but extremely fertile, and there is a theory that it was originally formed of volcanic ash, carried by the winds from St. Vincent during times when La Soufrière was in eruption.

It is said that the Portuguese were the first Europeans to visit the island; be this as it may, they never took possession of it. A British ship touched there in 1605, and, finding no inhabitants, annexed it in the name of King James I. Since that time British ownership has continued without interruption. An actual settlement was established in 1625, in which year the king made a grant of the island to Lord Leigh, afterward the Earl of Marlborough. Bridgetown, the present capital, was founded in 1628.

Barbados was the first of Great Britain's island colonies to grow sugar cane. The plant was brought there in 1642 during Philip Bell's governorship, and slaves were imported at the same time. A number of Dutch who were expelled from Brazil in 1655 took refuge in the island, and their knowledge of sugar and experience in its manufacture did much to stimulate the industry. Beginning with the middle of the seventeenth century, Barbados became an important sugar-producing center.

Following emancipation in 1834, the Barbados planters received £1,720,000 to indemnify them for the loss of over 83,000 slaves. At the same time a large number of the freed blacks continued to work on the sugar plantations as before, but under pay; hence abolition did not bring on the same hardships in Barbados as it did in some of the other West Indian colonies.

Labor is plentiful and cheap, so that cultivation is done carefully and in a thorough manner. The naturally rich soil is treated with fertilizers of various kinds, and planting is done every year as a rule, although ratoon crops are often raised on the uplands. Formerly Bourbon cane was grown exclusively, but owing to the falling off in the yield, it was discontinued and the varieties now in favor are White Transparent and seedling canes raised locally. The crops suffer from time to time through hurricanes and droughts, as well as from the common run of cane diseases. Of the entire area of 106,470 acres, about

100,000 acres are cultivated; between 60,000 and 70,000 acres of this are in sugar cane.

In 1902 there were 440 estates on the island, the average area being 168 acres. Of these, 23 exceeded 500 acres and 139 contained less than 100 acres; 19, comprising 6707 acres, were owned by corporations. Each estate had its own mill, and 432 of them made muscavado and eight of them centrifugal sugar. Today the number of factories is estimated at 335, of which 221 are driven by windmills. A few plants are equipped with vacuum pans and modern machinery, but muscavado sugar and molasses still represent nearly all of the production. The molasses obtained in the open-kettle process has a higher value and finds a much readier sale than that resulting from boiling in vacuum pans. Therefore in making comparisons between the yield in sugar from the open-kettle process with that from the vacuum-pan method, the increased price brought by the rich-flavored molasses made in the old-fashioned way must be taken into account.

On an average, the sugar content of the cane is 13.5 per cent and the recovery is about 7.5 per cent muscavado sugar and 3.5 per cent molasses. It is evident that imperfect crushing and crude manufacturing methods cause a considerable loss in sugar on most of the estates.

In 1898 the Imperial Department of Agriculture established its chief West Indian station in Barbados. This station has rendered great service to the planters in improving cane varieties, giving expert advice concerning fertilizing and fighting cane pests.

Undoubtedly much could still be done to better conditions, but the small estates are generally mortgaged and their owners are in no position to borrow more money to enable them to operate on a more extended scale. On the other hand, they are extremely tenacious of their holdings and will not part with

them to capitalists who might establish large central factories. It therefore seems altogether improbable that there will be any expansion in the sugar industry of the colony in the near future.

The production of Barbados during the last twenty years in long tons has been as follows:

| | | | | |
|---|---|---|---|---|
| 1895 | 33,331 | 1906 | | 50,630 |
| 1896 | 45,170 | 1907 | | 33,033 |
| 1897 | 51,275 | 1908 | | 31,353 |
| 1898 | 46,878 | 1909 | | 15,571 |
| 1899 | 40,442 | 1910 | | 36,389 |
| 1900 | 44,250 | 1911 | | 32,514 |
| 1901 | 56,912 | 1912 | exports | 30,548 |
| 1902 | 45,576 | 1913 | " | 11,479 |
| 1903 | 33,795 | 1914 | " | 33,387 |
| 1904 | 55,785 | 1915 | " | 32,578 |
| 1905 | 41,210 | 1916 | " | 50,000[1] |

[1] Estimated.

# TRINIDAD

TRINIDAD lies six miles off the northeastern coast of Venezuela, between 10 degrees 3 minutes and 10 degrees 50 minutes north latitude and 60 degrees 39 minutes and 62 degrees west longitude. Its average length is forty-eight miles, it is thirty-five miles in width and has an area of 1754 square miles. It is the largest of the British West Indian islands, with the exception of Jamaica, and the population in 1914 was estimated to be 255,148, one-third of whom were East Indians.

The surface is level or rolling, with a mountain range in the north, which rises to 3100 feet at its highest point, Tucuche Peak. In the south there is a ridge of hills about 600 feet high, and in the central part an upland belt runs from east to west by south. There are a number of small rivers, none of them navigable.

The island enjoys an equable climate, the temperature varying from 70 degrees to 87 degrees Fahrenheit, the mean being 78.6 degrees. The seasons are regular, rainy from May to January, with a four weeks' interval of fine weather in October, and dry from the end of January until May. The average rainfall is 66.26 inches, but in the cane-growing region it is about 80 inches. Hurricanes, earthquakes and long spells of drought are unknown.

Christopher Columbus discovered Trinidad in 1496 and the Spaniards occupied it ninety years later. It remained in their hands until 1797, when it was taken by the British, to whom it was formally ceded in 1802.

As was the case in other West Indian islands, the aborigines

were quickly exterminated by the Spanish conquerors and their places filled with negro slaves. A number of French and Creole settlers came to Trinidad in 1780, and about the middle of the following century Portuguese refugees from Madeira joined the colony. After the abolition of slavery by Great Britain in 1834, many Hindus were brought in under contract.

The soil of the island is very rich and well adapted to the growing of sugar cane and other tropical products. The sugar plantations are found in the level country bordering on the Gulf of Paria, where the soil is a dark clay, and which has been described as one of the finest stretches of sugar land in the West Indies.

As a result of the financial distress of 1895, which caused the home government to pass relief measures, a number of plantation owners were compelled to dispose of a portion of their land to farmers, who grew cane upon it and sold the crop to the sugar factories. It is estimated that today about twenty-five per cent of the cane worked up by the factories is furnished by these small growers, the remainder being raised by the owners of the estates. Grinding begins in January and is finished in May or June.

Trinidad has its own agricultural station, which is chiefly devoted to the study of sugar-cane culture. It has been of great service to the industry in determining the kinds of cane that can be most profitably grown, in fighting cane diseases and pests and in working out fertilization problems.

From 1855 to 1887 an average crop of 59,774 tons was turned out by ninety estates. Of this total, 28,500 tons were vacuum-pan sugar and the rest muscavado. In 1896, 62,975 tons of sugar were made by thirty-nine estates. Seven of these made 2000 tons of common muscavado, six made 5500 tons of centrifugal muscavado, and the remaining twenty-six made vacuum-pan sugar. A report made in that year concerning

sugar estates in Trinidad sets forth that advantage has been taken of the most modern improvements in boilers, furnaces, multiple evaporators, crushing mills and other machinery. Trinidad produces a large amount of what are known as "yellow crystals," which are sold in the British market for direct consumption and command a premium over the ordinary raw sugar.

Statistics compiled in 1909 show that the colony then had sixteen sugar factories, which turned out 52,972 tons of sugar, and the recovery represented 8.74 per cent of the weight of the cane; 451,801 tons of this cane were grown by the estates and 154,663 tons by the small farmers. There were 11,401 of the latter, 6077 of whom were East Indians and 5324 West Indians. Trinidad is the only West Indian colony where the attempt to fill the places of negro laborers with coolies from India has been successful. The production of sugar since 1900 has been as follows:

| | | | | | |
|---|---|---|---|---|---|
| 1900 | 41,269 tons | 1908 | | 48,933 | tons |
| 1901 | 51,077 " | 1909 | | 52,972 | " |
| 1902 | 44,913 " | 1910 | exports | 44,139 | " |
| 1903 | 46,029 " | 1911 | " | 37,282 | " |
| 1904 | 50,744 " | 1912 | " | 32,557 | " |
| 1905 | 38,240 " | 1913 | " | 31,665 | " |
| 1906 | 62,975 " | 1914 | " | 47,251 | " |
| 1907 | 50,564 " | 1915 | " | 49,107 | " |

1916 exports 55,000[1] tons

[1] Estimated.

# SANTO DOMINGO

HAITI is divided into two unequal parts, the republic of Haiti (République d'Haiti), comprising 10,204 square miles, and the republic of Santo Domingo (República Dominicana), with an area of 19,325 square miles. It is one of the four large islands of the West Indies and lies between 17 degrees 37 minutes and 20 degrees north latitude and 68 degrees 20 minutes and 74 degrees 28 minutes west longitude. Its length from east to west is about 407 miles and its greatest width is 160 miles. The total population is 2,737,700.

The surface of the island is exceedingly mountainous, three distinct ranges traversing it from east to west. The loftiest peak, Loma Tina, near the city of Santo Domingo, reaches a height of 10,300 feet. The extensive intervening valleys are fertile and watered by numerous rivers, none of which, however, are deep enough to be navigable.

The climate is hot and humid. An average temperature for the month of January would be about 75.4 degrees Fahrenheit, for July 84 degrees, and for the year 79.2 degrees. There are no active volcanoes, but great damage is done from time to time by earthquakes and hurricanes. The yearly rainfall is abundant, averaging about 120 inches. In San Pedro de Macoris, however, where the greater part of the sugar crop of the island is grown, the annual precipitation is in the neighborhood of 60 inches. As this is not sufficient for the needs of the growing cane, the planters have to do a certain amount of irrigating, and the water for this purpose is obtained from artesian wells.

The soil of the sugar-growing territory is of porous limestone

formation, which shows evidence of disturbances and upheavals due to volcanic agency. Overlying this is a deposit of decomposed vegetable matter from three to twelve inches in thickness, and there are areas where a rich black or red soil, varying from one to two feet in depth, is found.

On December 5, 1492, Columbus sighted the northern coast of Haiti and found safe anchorage there. The newly discovered island was named Española, which was afterward latinized to Hispaniola. Later still, the settlement founded by the Spaniards in the southern part under the name of Santo Domingo gave its name to the entire island. When Columbus set foot on its shores, Haiti had 2,000,000 inhabitants, who were governed by five caciques, each holding both religious and political sway over the separate kingdoms. At the outset the newcomers were received with welcome and honor, but it was not long before their tyranny caused a rupture between them and the natives. A war of extermination followed, and by 1506 the entire island had fallen into the hands of the invaders.

Left in possession of a depopulated country, the Spaniards restocked it with African negro slaves. Meanwhile the interior of the island had been explored, settlements had been established, mines opened up and progress made in agriculture. In 1506 sugar was brought in and its cultivation soon assumed important proportions. About 1625 the French and English began to give trouble to Spain in the western archipelago, and a few years later a number of Englishmen and Frenchmen, who had been expelled from St. Kitts by the Spaniards, took refuge on Tortuga island and became famous under the name of Buccaneers. They succeeded in establishing themselves in a part of Haiti, and in 1697 their right of possession was acknowledged and the territory occupied by them was ceded by Spain to France by the treaty of Ryswick. The new colony was called Saint Dominique, and it entered immediately into an era of

prosperity in which the expansion of the sugar industry was the principal factor. When the French revolution broke out, the exportations of sugar amounted to 80,000 tons, and this large production necessitated the employment of a great number of slaves. The whites were few and the unequal proportion led to disaster. The population consisted of whites, free colored people (most of whom were mulattoes) and negro slaves. The mulattoes demanded the same civil rights as the white people and these privileges were accorded them in 1791. Incensed beyond measure, the whites clamored loudly for a reversal of this decree and finally obtained it. On August 23, 1791, a violent insurrection of the blacks broke out; the plantation slaves were joined by the mulattoes and a massacre of the whites followed. Those who escaped the slaughter fled, leaving all their possessions behind; the sugar plantations were destroyed and the entire sugar industry came to an abrupt end.

In 1793 Saint Dominique was attacked by England and Spain, whereupon the French government, in order to conciliate the blacks and retain its dominion over the colony, proclaimed all the slaves free. By the terms of the Peace of Bâle in 1795, the whole island passed into the hands of the French.

Toussaint Louverture, a negro of marked military ability, was appointed commander-in-chief by the directory, and by 1801 he succeeded in restoring order. Unfortunately, the measures that he endeavored to put into effect aroused the suspicions of Napoleon, who sent out an army to subdue him and to restore slavery. This expedition met with such determined resistance that the commander, General Leclerc, opened negotiations and Toussaint was induced by solemn promises to lay down his arms. He was treacherously seized and taken to France, where he died in 1803. The blacks immediately renewed hostilities under Jean Jacques Dessalines, and in November, 1803, the French withdrew completely. In the follow-

ing year the independence of the island was declared and its ancient name of Haiti was restored. Dessalines was first made governor for life and in October, 1804, he proclaimed himself emperor. He was assassinated in 1806. From that time to the present the country has been in a state of turmoil and the end is not yet. In 1844 the people of the eastern end of the island seceded and formed the republic of Santo Domingo. Ever since then there have been two distinct governments in the island, with the strongest political antipathy existing between them.

But little sugar cane is raised in Haiti, and the most of this small quantity is either consumed as cane or made into a beverage called *tafia.*

The sugar plantations of Santo Domingo are found on the southern coast, in the level stretches of Arua and Romana, in the valleys near the city of Santo Domingo and in the region near San Pedro de Macoris. No sugar is grown in the interior. While most of the factories are land owners and cultivate cane, they do not grow all that they grind. A good deal is raised by colonos under the following conditions: The factories assign parcels of land to the colonos rent-free and in addition allow them the use of draft cattle and farming implements. When necessary a certain amount of actual cash is advanced. The colonos plant and till the land, furnish their own labor and deliver the cane at the point where it is loaded on the railway cars. The field hands are either natives or negroes brought from nearby islands, and their pay ranges from 50 to 75 cents gold per day.

The ground is tilled in an indifferent fashion and no fertilizing whatever is done. When virgin soil is planted, the seed is put in at seven-foot intervals, sometimes greater, without any holes or furrows having been made; the cuttings are simply stuck in the ground and partly covered with earth. The cane ripens in fourteen months or more. Ratooning follows until the

yield gets so small that replanting is necessary. When this time comes, the old roots are ploughed up and furrows from four to six inches in depth are made about five or six feet apart. The seed cane is planted in these furrows at four- or five-foot intervals. The yield from virgin soil is very heavy and has been known to reach ninety tons to the acre, but the sugar content of such crops is low, whereas the subsequent ratoons with a decreased tonnage of cane per acre give juice of a better quality. A fair average production on a plantation having 4000 acres in cane would be about twenty-four tons to the acre. Naturally this estimate would be affected by the relative proportions of plant cane and ratoons, as well as by the character of the soil. Planting is generally done in June and October, while the harvesting begins in December and continues until April.

Manufacturing methods in Santo Domingo admit of much improvement. Single crushing is the method employed for the most part, so that the loss in extraction is considerable. The juices are treated and the suspended impurities allowed to settle at the bottom of the tanks. Filter presses are the exception rather than the rule, and for want of them the sugar in the resultant mud is lost. The clear juices are then concentrated and boiled to grain in vacuum pans. First sugars generally polarize between 95 degrees and 97 degrees, seconds about 86 degrees. The molasses is either made into rum or permitted to run to waste. Notwithstanding the crude character of the factories and machinery, the recovery of sugar is generally good, the average being between 9 per cent and 11 per cent of the weight of the cane, with single crushing.

Almost all of the factories are managed by Americans, but, as has been said, the equipment they have to work with is by no means modern, and under the extremely uncertain political conditions that prevail there is scant encouragement for out-

side capital to come in and improve matters. Just when a change for the better will come is impossible to say.

Messrs. Willett & Gray give the yearly figures since 1903 in long tons, as follows:

| | | | |
|---|---|---|---|
| 1903-04 | 47,000 | 1909-10 | 93,003 |
| 1904-05 | 47,000 | 1910-11 | 89,979 |
| 1905-06 | 55,000 | 1911-12 | 96,046 |
| 1906-07 | 60,000 | 1912-13 | 84,661 |
| 1907-08 | 62,235 | 1913-14 | 105,778 |
| 1908-09 | 69,483 | 1914-15 | 108,267 |
| 1915-16 | 120,000 | | |

# GUADELOUPE AND MARTINIQUE

## GUADELOUPE

THE French West Indian colony of Guadeloupe consists of two islands that lie in the middle of the Leeward group between 15 degrees 57 minutes and 16 degrees 31 minutes north latitude and 61 degrees 10 minutes and 61 degrees 49 minutes west longitude. They are separated by a channel from one hundred feet to four hundred feet wide, called Rivière Salée.

Basse-Terre, the western island, is twenty-eight miles long, from twelve to fifteen miles wide and its area is 364 square miles. It presents a rugged surface, broken by hills and highlands, and a backbone of mountains runs through it from north to south. It is of volcanic origin, having been thrown up by four volcanic centers, Grosse Montagne (2590 feet), Les Mamelles (2536 feet and 2368 feet), Morne sans Toucher (4855 feet), and La Soufrière (4868 feet). The last-named volcano was in eruption in 1797, and in 1843 its disturbances wrecked several towns; today, however, the only evidences of life are a few hot springs and the emission of sulphurous vapors at certain points.

Basse-Terre is watered by a number of streams that become swollen and turbulent during the rainy season.

Grande-Terre, the eastern island, is low and level, the greatest elevation being only 450 feet. It consists of a plain of limestone formation with a conglomerate of sand and broken shells. It is about twenty-two miles long from north to south and its area is 255 square miles. The population is 190,273, chiefly negroes and mulattoes. For water supply it is dependent upon

ponds and cisterns, as, owing to the porosity of the soil, no rivers or streams exist.

The climate is warm and humid. The mean yearly temperature is 78 degrees Fahrenheit, the minimum 61 degrees and the maximum 101 degrees. The wet season is from July to November, and on the coast the annual rainfall is about eighty-six inches, with a great deal more in the interior. Terrific storms visit the island and hurricanes have wrought much destruction.

The soil is fertile and rich and the principal crop is sugar cane, which is grown on over half the total cultivated area. The principal sugar centers are Point-à-Pitre, St. Anne and Le Moule in Grande-Terre, all of which have well-appointed usines. There is also a large usine in Basse-Terre.

Guadeloupe was discovered by Columbus in 1493. One hundred and forty-two years afterward l'Olive and Duplessis took possession in the name of a French company called the Compagnie des Iles d'Amérique. The native Caribs did not long survive the cruel treatment accorded them by l'Olive, and efforts at colonization were the reverse of successful, in fact four chartered companies were ruined in the attempt. In 1674 the islands passed into the possession of the French crown and they were governed from Martinique for a long time. In 1759 they were captured by the British, in whose hands they remained for four years. The British again occupied them in 1794, but were driven out the following summer by Victor Hugues with the help of liberated slaves. The last British occupation took place during the Hundred Days of 1815, and they finally withdrew in 1816. Slavery in Guadeloupe was abolished in 1848.

### MARTINIQUE

The French colony of Martinique is the most northerly of the Windward islands. It is situated between 14 degrees 55 minutes and 14 degrees 23 minutes north latitude and 60 degrees

48 minutes and 61 degrees 16 minutes west longitude. Its area is 381 square miles, its greatest length from northwest to southeast 36 miles, and its extreme width 18 miles. The population, negroes and half-castes for the most part, numbered 190,000 in 1913.

The surface is mountainous, the highest peak being Mt. Pelée, which rises 4428 feet above sea-level. The appalling eruption of this volcano in May, 1902, was one of the greatest disasters of modern times and cost the lives of 40,000 people. About one-third of the island's surface consists of extensive plains, most of them occurring in the south. The soil of the northern part is of volcanic formation, while in the south it is composed of clay. There are a number of streams, some of them of considerable size.

Near the coast the average temperature for June is 83 degrees, and for January 77 degrees, the mean for the year being about 80 degrees Fahrenheit. The wet season extends from June to October and the total yearly rainfall approximates 87 inches. August is the wettest month and March the driest. In the low region of the sea coast the climate is not healthful for Europeans during the hot period, but a more salubrious atmosphere and a temperature 10 degrees lower is found in the wooded uplands, 1500 feet above the sea. Fresh, dry northerly winds prevail from November to February, easterly winds from March to June, and damp, warm southerly winds from July to October. Earthquakes are frequent, but hurricanes seldom visit the island.

Martinique was discovered by Columbus on June 15, 1492, and the French Compagnie des Iles d'Amérique took possession of it in 1635. It was settled in the same year by Pierre Belain, captain-general of the island of St. Christopher, and in 1674 it became the property of the crown.

Sugar culture was begun in 1650, and a few years later the

aboriginal Caribs were exterminated, their place being filled by negro slaves, of whom there were 60,000 in the island by 1736. Slavery was abolished in 1848.[1]

During the seventeenth century Martinique was attacked several times by the British and the Dutch. It was captured in 1762 by the British under Admiral Rodney, but restored to the French in the following year. It was held by the British from 1793 to 1801 and also between 1809 and 1814.

The capital of the island is Fort de France, on the west coast. It is situated upon a fine harbor and has 18,000 inhabitants. Besides the chief product, sugar, the colony raises coffee, cocoa, tobacco and cotton.

### GUADELOUPE AND MARTINIQUE

Sugar planting in these islands dates from 1635, the year in which they were first occupied by the French, and the industry grew apace, so that much sugar was exported to France during the latter half of the seventeenth century. The import duties levied by France in 1664 shut out foreign raw sugars from that country, while protecting raw sugars from her colonies; but at the same time the tariff laws excluded white sugar produced in the colonies. This was a death blow to the refineries of Martinique. A decree entirely prohibiting the refining of sugar in the colonies and the exportation of raw sugar to foreign countries was issued in 1669, while an export duty was imposed upon the raw sugar shipped to France. The tax upon raw sugar was removed in 1682, but the duty on refined was increased. The colonial planters then turned their attention to the manufacture of clayed sugars, which they sold in North America and southern Europe.

In 1717 France established relations with her colonies that were almost tantamount to free trade. No duties were assessed

[1] *Britannica* says 1860.

upon French goods going into the colonies, and commodities produced in the colonies entered the mother country without duty. As a result of this policy, the sugar industry grew until the production of Guadeloupe, Martinique and Saint Dominique was more than France could consume, and a law was passed permitting the sale of the surplus in other countries.

During the closing years of the eighteenth century, the war between England and France crippled the trade of the French West Indies, but when peace was finally restored the sugar industry revived and continued to flourish until the abolition of slavery in 1848.

When the slaves were freed, the planters cast about them to find laborers, and India was one of the first sources of supply. Over ten thousand Hindus were brought to Martinique between 1852 and 1862, and with very few exceptions they remained in the island after their five-year contract expired. During the twenty-two years that followed 1862, 25,500 laborers came to Martinique from Pondicherry, Yanaon, Karikal and Calcutta with the permission of the Indian authorities, but emigration from that country under government auspices was discontinued in 1885. In addition to Hindus, free African negroes, Chinese and Annamese were brought in.

The sugar plantations of Guadeloupe and Martinique are situated on the low, alluvial lands around the coast, although some are found in the interior. The hilly character of the latter, however, is not favorable to cane culture, as the heavy rains wash the arable soil down the slopes, thus interfering with the growth of the cane.

The ground to be planted in cane is first cleared and then ploughed. Furrows about two feet deep and four and one-half feet apart are then made and the seed cane is planted in holes five inches deep. Three weeks afterward the cane is banked and fertilizer applied. The soil between the canes is loosened

from time to time and the crop is cut after a year's growth. As a rule, ratooning is limited to two years, one crop being produced each year. The land is then allowed to rest for a time, after which planting is begun anew.

Bourbon cane is the variety principally grown, although seedling canes have been brought in from Barbados and British Guiana of late years. The average yield per acre of plant cane is twenty-four tons; first ratoons give sixteen tons and second ratoons about eight tons. After the cane is cut it is loaded on large carts and taken to the factories. Some estates are equipped with field railways, the cars being drawn by mules or locomotives.

As mentioned in the chapter on Jamaica, the early sugar producers of Saint Dominique, Guadeloupe and Martinique excelled the manufacturers of the other West Indian islands in the preparation of the commodity. The result was that their lead was gradually followed by the others, and a brief description of the methods they employed will be of interest.

The cane juice was boiled in a series of five or six copper kettles placed over a furnace fed by bagasse and wood. These kettles were of different sizes, the largest being farthest from the fire and the size of each decreased as the furnace door was approached, the smallest being directly above the fire. The kettle next to the largest was set a little higher than the largest one, the third higher than the second and so on until the last and smallest, which was the highest of the series. Clarification was done with lime and wood ashes, and sometimes a little crude antimony. As soon as the raw juice reached the first and largest kettle the clarifying material was thrown in and the boiling began. The scum was removed as soon as it formed, and when the juice became sufficiently clear it was quickly transferred to the second kettle; a small amount of alkali was mixed with it and further boiling and skimming was done. The liquor was then

ladled into kettle number three, potash lye and an extract of herbs were added, and after being boiled for a time it was passed to kettle number four, and finally concentrated in the last and smallest kettle immediately above the fire. When the required consistency was reached, the massecuite was put into vessels to cool, at the same time being kept in motion by stirring until the grains began to form. It was then placed in moulds, and after having become thoroughly cool it was dumped into hogsheads that had perforated bottoms. These hogsheads stood on racks, beneath which there was a receptacle to catch the molasses as it drained off through the holes in the bottom. The draining was allowed to continue until about one-half the weight of the contents of the hogshead was crystallized sugar. The holes were then plugged up and the sugar was ready for shipment. The molasses was manufactured into rum.

A superior grade, called *sucre terré*, or clayed sugar, was also made. In its preparation, juice from the best and ripest cane was taken and as little lime as possible was used in clarification. Antimony was excluded entirely, on account of its tendency to darken the color of the juice. As the juice was transferred from kettle to kettle during the various boilings, it was strained through a cloth each time, instead of being ladled direct from one kettle to the next. When the syrup was concentrated it was put into earthenware sugar-loaf moulds that held between thirty and thirty-five pounds of massecuite apiece. These moulds had perforations in the bottom that were stopped up before the mass was put in. In filling a mould, one quarter of its capacity was put in at one time, making four operations. Fifteen minutes after the last lot of massecuite was put in the mould, a layer of crystals formed on the surface, and this was thoroughly stirred into the mass, which was then left to cool. A couple of days later the plugs were removed so that the molasses might drain from the mould. In case it did not run off

properly, the massecuite was remelted, but if the drainage was satisfactory, the next step was the claying of the sugar. If the top of the loaves was uneven or dark-colored, it was scraped smooth and covered with a layer of crushed sugar. The surface was then hammered level and even. A special kind of clay brought from Rouen was mixed with water and the mould was filled to the top with this mixture. Windows and doors were shut to prevent evaporation of the moisture, and the water draining from the clay gradually passed down through the sugar crystals, washing the syrup from them. After ten days had elapsed, the clay, then thoroughly dried, was removed, the surface of the sugar-loaf was cleaned, another layer of wet clay was applied and allowed to remain as long as the first. When this second layer was taken off, the loaves were removed from the moulds and allowed to dry in the air for a time. Further drying was done in a drying room, heated for the purpose, and the sugar, when all the moisture had been driven from it, was crushed by wooden pestles. Refined sugar was packed for shipment in casks containing between 600 and 700 pounds. The first molasses was made into rum or boiled into second sugar, and the syrup washed from the loaves was made into a sugar called *cassonade*.

This primitive method of manufacture has been entirely supplanted by newer processes and appliances. As a rule, today cane is crushed twice and maceration is often employed. The juice is treated with sulphur while still cold, and it is then pumped into defecation tanks, where powdered lime is added; after this is done heat is applied. As soon as the scum cracks, the steam is turned off and the clear juice is separated from the sediment by a siphon and run to the evaporators, while the muddy precipitate goes to the filter presses.

Concentration of the juice takes place in double, triple or quadruple effects of rather an old type, which means lack of

economy in steam and consequent large fuel consumption. As the quantity of bagasse available does not afford sufficient fuel to generate all the steam that is required, a considerable amount of wood and coal is used in addition for the purpose. The unwise and short-sighted policy of denuding the hillsides of their timber has had the effect of lessening the rainfall, a condition that has brought great injury to the planter.

The vacuum pans are small and of old style; the centrifugal machines, too, are of obsolete design and slow to operate. After the liquor has been boiled to grain in the pans and the sugar crystals have been separated from the mother liquor in the centrifugals, the sugar is dried and packed for the market in barrels or bags. The first molasses is reboiled and the resulting massecuite sent through the centrifugals. After this operation has been repeated three or four times, the final molasses is made into rum.

Today there are eighteen factories in Guadeloupe and fifteen in Martinique. The average extraction of sugar is 9.70 per cent of the weight of the cane, the loss of sugar in the bagasse is 2.15 per cent, the mechanical loss in manufacture is .90 per cent, and the percentage of sugar not recovered from the molasses is 1.75. This gives an average total of 14.50 per cent of sugar in the cane.

The manufacturers are dependent upon the small farmers for their raw material, and the price paid for the cane is determined by a very complex agreement, which nevertheless seems to be entirely satisfactory to both buyer and seller.

The outlook for the sugar industry in Guadeloupe and Martinique is far from bright. There is labor in abundance, but the natives are averse to working steadily, and consequently are unreliable. There are great possibilities for improvement, but little can be expected under the circumstances that prevail at the present time.

Since 1894 the production of the two islands in long tons has been as follows:

| | MARTINIQUE | GUADELOUPE |
|---|---|---|
| 1894 | 36,353 | 42,395 |
| 1895 | 28,777 | 29,394 |
| 1896 | 33,886 | 42,616 |
| 1897 | 34,185 | 39,493 |
| 1898 | 30,971 | 36,550 |
| 1899 | 31,165 | 39,259 |
| 1900 | 33,234 | 27,895 |
| 1901 | 39,121 | 38,086 |
| 1902 | 38,905 | 39,995 |
| 1903 | 28,578 | 37,891 |
| 1904 | 23,561 | 35,348 |
| 1905 | 29,986 | 26,905 |
| 1906 | 42,231 | 42,535 |
| 1907 | 36,764 | 38,345 |
| 1908 | 35,943 | 35,485 |
| 1909 | 37,757 | 24,812 |
| 1910 | 39,950 | 44,289 |
| 1911 | 35,438 | 38,384 |
| 1912 | 39,433 | 39,368 |
| 1913 | 40,000 | 32,000 |
| 1914 | 38,730 | 39,920 |
| 1915 | 40,000 | 40,000 |
| 1916 | 40,000 | 40,000 |

# MEXICO

THE United States of Mexico lie between 14 degrees 30 minutes and 32 degrees 42 minutes north latitude and 86 degrees 46 minutes and 117 degrees 7 minutes west longitude. On the north the boundary is the United States of America; on the east the Gulf of Mexico, the Caribbean sea, British Honduras and Guatemala; on the south British Honduras and the Pacific ocean, and on the west the Pacific ocean. The superficial area of the country is 765,537 square miles. Its greatest length is 1942 miles and its greatest width is 762 miles. It has a coast line of 5486 miles, of which 1603 miles are on the Gulf of Mexico and the Caribbean sea and 3883 miles on the Pacific ocean and the Gulf of California.

The surface of Mexico rises sharply from the seacoast levels by a series of terraces to a central plateau, that varies in height from 4000 to 8000 feet and runs northwest and southeast. This tableland has been formed by the material deposited during the gradual erosion of the mountains and by matter thrown up by a great number of volcanoes. In this manner the original valleys became completely filled up and those that now exist are of later formation. To illustrate this filling process, buried mountains whose peaks appear above the surrounding mass are found in the higher parts of the plateau, while elsewhere they are met with as continuous ridges. The eastern coast is low and sandy, except in a few places where the mountains come down close to the shore. The Pacific coast lands are also low, but occasionally broken by mountain spurs. Owing to the terraced character of the country, very little river navigation is possible, but on the other hand an enormous amount of power

can be developed from the numerous waterfalls. Two high mountain ranges, one on each coast, run parallel to the sea the entire length of Mexico. The eastern chain is about ten miles inland, while on the west there is only a narrow shelf of land between the sea and the cordilleras. This western range has several branches that run in different directions, the most important being the Sierra Madre Occidental. In Mexico the highest mountains are volcanoes. On the Pacific side and west of the plateau are found the Volcán de Colima (12,750 ft.) and the Nevado de Colima (14,354 ft.). Southwest of the City of Mexico is the Nevado de Toluca (16,610 ft.) and to the south and east are the snow-crowned giants Popocatepetl (17,540 ft.) and Ixtaccihuatl (15,705 ft.). Still farther east are Orizaba (16,176 ft.) and Cofre de Perote (14,309 ft.). Popocatepetl and Orizaba may be classified as dormant cones, for the reason that aqueous and sulphurous vapors are constantly being emitted from their perfectly formed craters. One of the highest lakes in the world is found in the crater of the Nevado de Toluca. Colima has been in eruption continuously for many years and is still active. The snow never leaves the summits of Orizaba, Popocatepetl and Ixtaccihuatl, and on the last the ice cap attains a development sufficient to form true glaciers.

On the western coast the principal ports are Guaymas, Mazatlan, Topolobampo, Acapulco, La Paz and Salina Cruz; on the eastern seaboard, Tampico, Vera Cruz, Puerto Mexico, Campeche and Merida. Of the numerous rivers, the most important is the Río Grande, 1550 miles long, which forms a natural boundary between Mexico and the United States from El Paso to the Gulf. However, the conformation of the country does not admit of river navigation to any extent.

According to the census of 1910, the population was 15,063,-207, of which 20 per cent were whites, 43 per cent of mixed blood and the remainder of Indian extraction.

In Mexico there are three distinct climates and a wide range of temperature. The hot country, *tierra caliente,* extends from the seacoast inland to an altitude of about 3000 feet. Here the mean annual temperature is between 80 degrees and 88 degrees, and the highest between 100 degrees and 105 degrees Fahrenheit. In this region the winter climate is delightful, except when severe gales sweep down from the north. In summer the extreme heat is not so great as in New York, because of the moderating effect of cool breezes.

The temperate region, *tierra templada,* extends from 3000 to 6500 feet above sea-level, and it is here that the ideal climate of Mexico is found, the mean annual temperature being between 73 and 77 degrees Fahrenheit, with a total variation of possibly not over 6 or 8 degrees during a season. In this dry, clear atmosphere the hygienic disadvantages of the seacoast, the sharp, cold winds of the upper altitudes, sudden changes in temperature, heavy frosts, extreme humidity and harmful insects are unknown, and in the dry season there is no malaria.

Tropical and semi-tropical growths flourish side by side, and there are estates on which wheat and sugar cane are raised almost in touch of each other.

The cold country, *tierra fria,* extends from the 6500-foot level to the snow line, but here the term cold is used in a comparative sense, as distinguished from the heat of the seacoast. The average temperature runs between 59 degrees and 62 degrees Fahrenheit, with slight variations. At times, however, a norther will drive the mercury down to 40 degrees or 35 degrees and sprinkle the streets of Mexico City with white.

As a rule, in Mexico the rainy season begins in May or June and ends in October. The annual rainfall varies greatly according to locality, ranging all the way from fifteen to fifty inches. Earthquakes are of common occurrence, especially on the western coast.

Sugar cane was brought to Mexico by the Spanish conquistadors. Prescott, in his "Conquest of Mexico,"[1] says that the sugar cane was transplanted from the neighboring islands to the lower level of the country, and that, together with indigo, cotton and cochineal, it formed a more desirable staple for the colony than its precious metals. He also states that it was Hernan Cortés himself who introduced the cane from Cuba. This famous soldier established the Atlacomulco plantation, which lies an easy hour's ride distant from Cuernavaca in the state of Morelos, and there, in 1520, a hundred years before the landing of the Pilgrim Fathers at Plymouth, he erected the first sugar mill in Mexico. This mill is owned by the descendants of Cortés and is still in operation.

Thirty years later sugar was shipped from Mexico to Peru and Spain, and the production of the commodity was maintained steadily until 1791. In that year all the cane-growing countries of western America received a stimulus from the wholesale destruction of the plantations and mills of Santo Domingo.

In Mexico natural conditions are very favorable to sugar culture, but the growth of the industry has been retarded by the primitive methods in vogue, the inadequacy of transportation facilities and political disturbances. In the seaboard states the sugar plantations are found chiefly in the rich lowlands bordering on the Pacific ocean and the Gulf of Mexico. In the Gulf states the rainfall is ample to insure good crops. The largest sugar producer, however, is the inland state of Morelos, and there, as well as on the west coast, irrigation is necessary. The higher levels do not give such good crops as the lowlands; on the latter the yield is between forty and sixty tons to the acre, and on the former it runs between twenty-five and forty-five tons to the acre. Sugar beets have been grown on the plateau

[1] Vol. III, pp. 256-318 (Dana Estes & Co.'s edition).

with marked success. In the low, tropical regions seven or eight crops of ratoons can be raised, but on the higher lands replanting must be done every two or three years. The best-known plantations are situated on large estates that have been owned by the same families for many generations. For instance, in Morelos, where about sixty per cent of Mexico's crop is produced, the estates are owned by non-resident families and, as a rule, managed by Spaniards. Labor is cheap and abundant, the cane is rich in juice and the sugar content is high, but the extraction in the small, crude mills is poor, the recovery of sugar, as a rule, not exceeding six per cent of the weight of the cane. There are a few large factories in Mexico where the methods and results should be more closely in accordance with modern practice.

The nineteenth century saw the industry maintained on a fairly even basis, but about 1900 an improvement was noted, as the following table will show:

| | | | |
|---|---|---|---|
| 1899-1900 | 75,000 tons | 1907-1908 | 123,000 tons |
| 1900-1901 | 95,000 " | 1908-1909 | 143,000 " |
| 1901-1902 | 103,000 " | 1909-1910 | 148,000 " |
| 1902-1903 | 112,000 " | 1910-1911 | 161,602 " |
| 1903-1904 | 107,000 " | 1911-1912 | 151,735 " |
| 1904-1905 | 107,000 " | 1912-1913 | 148,672 " |
| 1905-1906 | 107,500 " | 1913-1914 | 130,000 " |
| 1906-1907 | 119,000 " | 1914-1915 | 110,000 " |
| 1915-1916 | 75,000 tons | | |

The effects of the internal disturbances in Mexico are plainly reflected in the crop figures. In addition to the sugar tonnage shown, about 50,000 tons of *piloncillo* or *panela* (concrete sugar) are turned out annually by the small mills and the production of molasses is large. A considerable amount of the latter is used in the manufacture of rum and alcohol.

As regards the future of sugar in Mexico, there is much to justify belief in ultimate expansion and prosperity. Labor is cheap and plentiful, there are vast tracts of rich virgin land awaiting cultivation, irrigation possibilities are great, and when the present political disorders shall have been quieted and stable conditions established, a movement forward will surely follow.

# PERU

PERU is situated on the west coast of South America and extends from 3 degrees 21 minutes to 18 degrees south latitude and from 70 degrees to 81 degrees 40 minutes west longitude. Its area, including certain disputed territory, is 676,638 square miles. Physically, it is divided into three distinct regions, the coast, the sierra and the montaña. In the first, or the dry side of the Andean slope, spurs run out from the main range of mountains toward the ocean, forming extensive valleys, some of which are well watered and very fertile. The spaces that lie beyond the life-giving influence of the rivers have the appearance of sandy deserts, but they only need water to make them productive. The Andes proper occupy the sierra region, which abounds in plateaus, deep ravines, rich sheltered valleys and snow-capped mountains of stupendous height. East of the Andes lies the montaña, or wet side. It is traversed by broad navigable rivers and embraces the sub-tropical forests in the ravines and on the eastern slopes of the Andes, as well as the dense tropical forests of the wide valley of the Amazon.

According to the 1915 edition of the Century atlas, the population is 4,609,999. About 57 per cent of the inhabitants are Indians, 13 per cent whites, 2 per cent Asiatics, 2 per cent negroes, the remainder being mixed races.

The sugar plantations are found on the west or dry side in the coast region.

The valleys of this coast country have been upraised from the ocean at a comparatively recent geological period, and the fertile soils of these valleys are the result of erosion and deposit through the agency of mountain torrents.

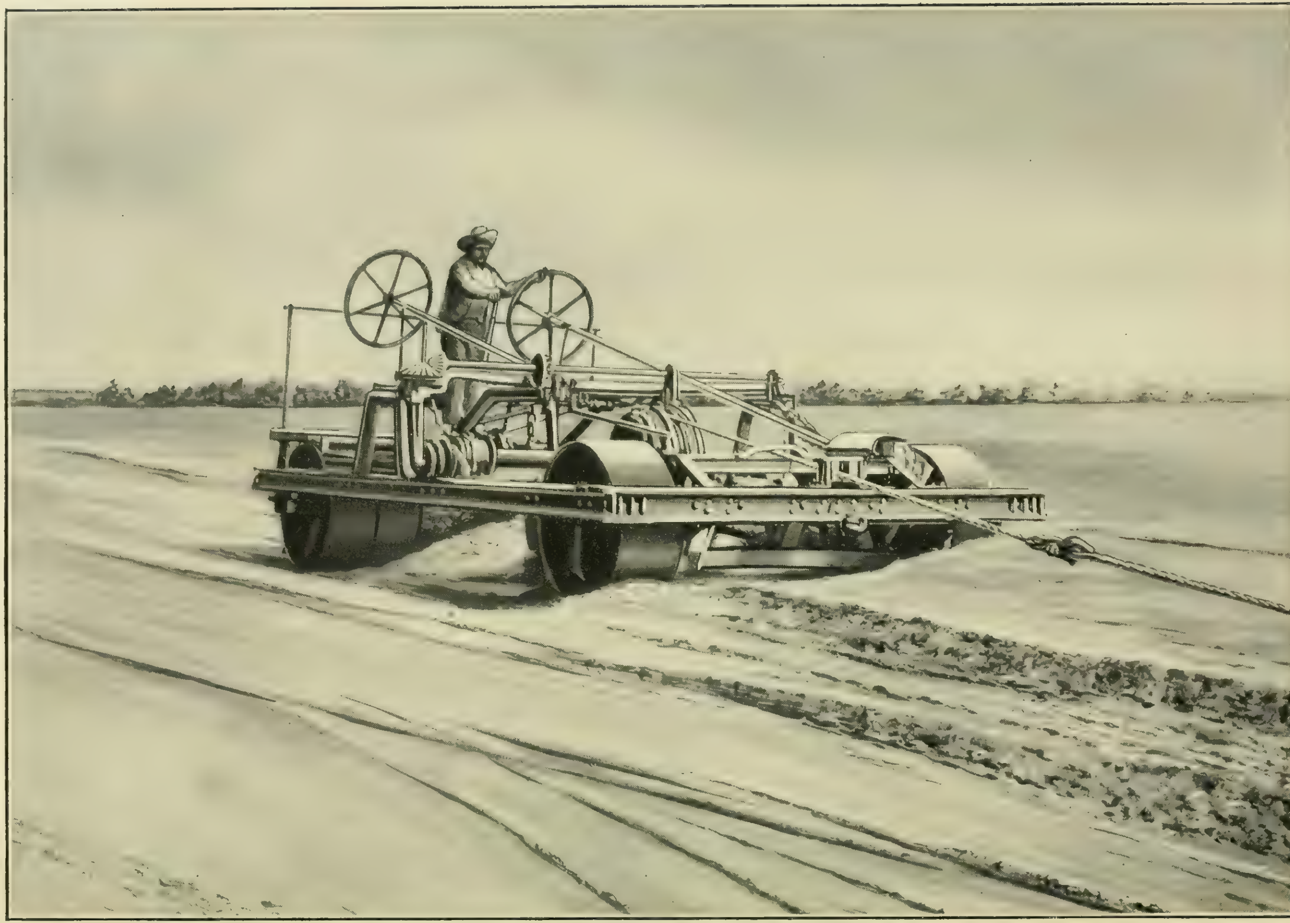
The most important cane-growing districts lie seven or eight degrees south of the equator, and yet the climate of that section cannot be called really tropical. It is influenced by the cold antarctic currents and the steady winds that sweep northward. Observations on the Cartavio plantation during the period 1904-1907 showed the highest maximum temperature to be 95.5 degrees and the lowest minimum to be 52 degrees Fahrenheit. In the coast territory the rainfall is limited and the cane crops depend upon irrigation.

The soils of the coast valleys range from silt to an extremely fine sandy loam, and vary in thickness. As a rule they are deep, retentive of moisture, well drained, rich in plant food, easy to cultivate and, with intelligent treatment, very productive.

Ricardo Palma, in his work, "Tradiciónes Peruanas," sets forth that sugar cane was not known in Peru when Francisco Pizarro and his followers first landed there in 1527, but that it was brought in a short time afterward. The first plantation was established in 1570 and the first factory was erected on an estate in the valley of Huañuco. Meanwhile, the sugar used in Lima came from Mexico, and the owner of the Huanuco mill, realizing that his product could not compete with Mexican sugar, had recourse to a clever stratagem. He loaded a vessel with sugar and sent her to Mexico. The ruse was successful, for the Mexican manufacturers at once concluded that if sugar could be shipped from Peru to Mexico, the production must be large and the cost very low. Consequently, they discontinued their shipments from Acapulco to Peru, much to the advantage of the astute factor of the Huanuco valley. In the beginning, the estates were worked by slaves, and, as happened in other sugar countries, after the abolition of slavery the plantation owners were compelled to look abroad for their laborers. As many as 90,000 Chinese were imported from Macao[1] between

[1] Portuguese settlement at the mouth of the Canton river.

LEVELING A CANE FIELD, PERU



LEVELING GROUND BY STEAM, PERU

1849 and 1874, but so many of them succumbed to the severe treatment they received that the Macao authorities put a stop to the labor traffic altogether. The Chinese living in Peru at the present time are tradespeople and the work on the sugar plantations and in the mills is done by the native Indians.

The year 1860 marked an important change in the industry, which up to that time had been carried on in a very primitive manner. A large amount of fresh capital was put into sugar enterprises, new mills were built, the most approved machinery was installed and the factories were equipped with the best appliances that money could buy. The apparatus for some of the plants was brought from the United States, while that for others was supplied by European countries, so that the methods and workmanship of various nationalities are found in the Peruvian factories. No expense was spared in any department and all went well so long as the price of sugar kept up; what was easily made was liberally administered, but when in 1875 the market dropped, severe competition drove many operators into difficulties and a number of them went under entirely. The war with Chile in 1878 and the subsequent revolutionary disturbances impeded the progress of the industry, but a restoration of tranquillity came in 1895, and since then the sugar business of Peru has prospered and increased in volume.

An experiment station was established near Lima in 1906 for the study of cane cultivation, irrigation problems and the improvement of yield and quality by the introduction of new varieties of cane. The manufacturing side of the question has also been gone into with great care, and much is being done to increase efficiency in that direction.

Today there are 47 modern factories in Peru and 125,000 acres planted in sugar cane. Outside of these modern plants, crushing is also done in a crude manner in wooden-roller mills on small plantations that are scattered throughout the interior.

The juice obtained in this way is worked up to *chancaca*[1] or *panela* or made into an alcoholic beverage called *cañaso* or *chacta.*

As the plantations do not depend upon any special season of rainy or dry weather, planting and harvesting may be done at any time. In Peru the land upon which sugar cane is grown is generally gently sloping. On the large haciendas, when preparing virgin soil for planting, the brush is first cleared away and the holes filled. The ground is then ploughed and cross-ploughed by steam-ploughs and broken fine by clod-crushers; roadways and drainage ditches are laid out, forming squares or rectangles, and furrows are made at intervals of three to four feet. This done, the ground is ready for planting. The cane tops used for seed are cut during harvesting, loaded on cars and sent to the field that is to be planted. The seed cane is placed horizontally in the furrow and covered with a few inches of earth, and as soon as the whole field is planted in this manner, water from the irrigation ditch is turned in and the cane left to grow. The first weeding is done when the cane shoots are a foot high, and it is continued at intervals until the cane leaves become large enough to shade the ground and prevent weed growth. The cane matures in from eighteen to twenty-four months, according to location, soil and weather conditions. Some weeks before harvesting, irrigation is discontinued in order to allow the cane to ripen.

In cultivating the first ratoons, when the cane gets to be a few feet high the crest of the furrow is thrown down into the furrow so that the irrigation water passes between the rows of cane instead of along the furrows, as in the case of plant cane.

Ratooning is kept up until it ceases to be profitable. At the

[1] *Chancaca* is made by boiling the cane juice in open pans to the consistency of massecuite, then running it into moulds about six inches in diameter and allowing it to cool.

PLANTING CANE, PERU

PORTABLE BRANCH LINE OF FIELD RAILWAY AND CANE CUTTERS, PERU

Hacienda Cartavio, four ratoon crops have been grown in some places, and as many as seven in others, with good results.

The principal ingredient of the fertilizer used is guano, which is mixed with lime, nitrate of soda, potassium sulphate, or ashes from the bagasse furnaces, and it is applied in various ways. Some planters throw it in the furrows with the seed cane and allow it to remain there a time before turning on the water; others place it in the furrows a few months after the planting and cover it immediately, while still another method is to apply it and turn on the water at the same time. On certain plantations the fertilizer is ground and spread over the entire field just before replanting.

Water for irrigating is obtained from the mountain streams, which are dammed at certain points, and but little is pumped from wells. The quantity needed is far less than in Hawaii, owing to the nature of the soil and the presence of underground moisture close to the surface. A fixed amount is assigned to each estate by the government and this is never exceeded during the dry season. In flood time, however, the regulations are somewhat relaxed, as there is then enough for all and to spare.

The water is brought on the land by large ditches, and thence to the cane fields through smaller ones. From these field ditches it flows directly into the cane rows at the upper end of the field or section, and, owing to the slight slope of the land, it passes freely through the parallel rows from the upper to the lower end of the section. It is retained in the furrow by means of a dam at the lower end. Other ditches are made at the lower ends of the sections for drainage purposes. The amount of irrigating done varies according to the nature of the land; in some cases water is applied only once during the season, in others as many as twenty-four times. The average number of waterings is five.

When the cane is ripe it is cut by laborers with heavy knives, or machetes, and loaded by hand into cars that run through the

fields on portable tracks. These cars, which hold from two to ten tons each, are made up into trains and drawn by a locomotive to the mill. The average yield per acre in 1912 was about 34 tons, but the planters are seeking for better results through improved field methods and new varieties of cane. Pests and disease do little damage in Peru, although the borer gives some trouble. Owing to the long period of growth in a dry climate, Peruvian cane is high in fiber and low in juice, but the juice is rich and very pure; this combination of high fiber content and high percentage of sugar in the juice, however, brings about an unusual loss of sugar in the bagasse.

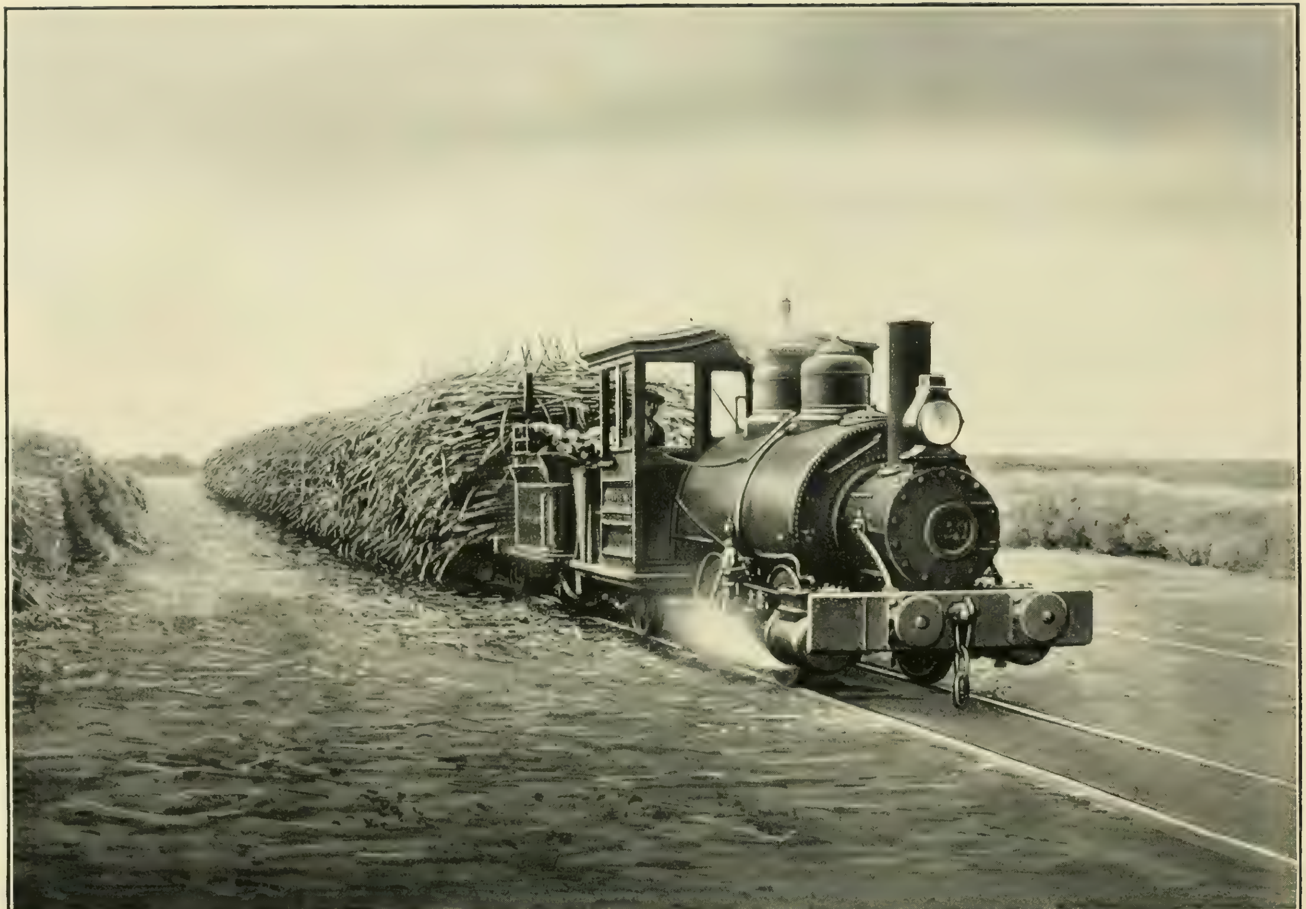
Nearly all of the sugar manufactured is a coarse-grained centrifugal raw, polarizing about 96.5 degrees and known to the trade as "Peruvian crystals." Part of it is marketed in the United States and the rest goes to Great Britain, while the second and third sugars are sent to Chile to be refined there. A certain amount of white sugar for home consumption is made by washing the brown centrifugal sugar.

At the beginning of the Chilean war the output was approximately 80,000 tons. In 1905 the production of sugar and molasses was 159,294 long tons, and 132,222 tons of this were exported.

The following table gives the outturn in long tons since 1905:

| YEAR | CONSUMPTION | EXPORTS | TOTAL |
|---|---|---|---|
| 1905 | 27,077 | 132,136 | 159,213 |
| 1906 | 32,178 | 134,592 | 166,770 |
| 1907 | 30,110 | 108,886 | 138,986 |
| 1908 | 31,895 | 122,940 | 154,836 |
| 1909 | 29,173 | 123,393 | 152,567 |
| 1910 | 29,189 | 119,744 | 148,933 |
| 1911 | 31,988 | 121,758 | 153,745 |
| 1912 | 36,129 | 145,106 | 181,236 |
| 1913 | 34,976 | 140,669 | 175,645 |

HAULING CANE-LADEN CARS WITH OX-TEAM, PERU



TRAIN-LOAD OF CANE EN ROUTE TO THE FACTORY, PERU

| YEAR | CONSUMPTION | EXPORTS | TOTAL |
|---|---|---|---|
| 1914 | 32,555 | 173,910 | 206,465 |
| 1915 | 40,000 | 208,487 | 248,487 |

The possibilities for expansion in Peru's sugar industry are large. Further impounding and conservation of the flood waters from the mountains would bring under cultivation many thousands of acres that are now unproductive. Good flowing wells have been sunk on some estates, and it is likely that many more will be found, thus adding substantially to the present water supply. As to cost, it would seem that Peru should be able to compete successfully with other cane-growing countries. The plantation lands are level or slightly sloping, so that cultivating machinery may be used to good advantage. Grinding can be carried on without interruption throughout the year, which means economical factory capacity and an even distribution of labor. The cost of labor, too, is reasonable, and great quantities of fertilizers lie close at hand. In short, Peru enjoys many advantages, and if her planters and refiners keep pace with scientific development, she will take a prominent place among the cane-sugar countries of the world.

# BRAZIL

BRAZIL is the largest political division of South America. Its area is 3,270,000 square miles, or slightly greater than that of the United States, excluding Alaska. From Cape Orange, in 4 degrees 21 minutes north latitude, it extends 2629 miles southward to the river Chuy, in 33 degrees 45 minutes south latitude, and from Olinda 2691 miles west to the Peruvian border, between 34 degrees 50 minutes and 73 degrees 50 minutes west longitude. According to the latest census returns at hand, the population numbers 20,515,000.

Speaking generally, Brazil is a tropical country with subtropical and temperate regions in the south and in a large part of the high central plateau. The sugar-producing states are Maranhão, Rio Grande do Norte, Parahyba, Pernambuco, Alagoas, Sergipe, Bahia, Minas Geraes, Rio de Janeiro and São Paulo. The plantations themselves lie between 4 degrees and 21 degrees south latitude, and being swept by the moisture-laden eastern trade winds, they receive a fair amount of rain during the wet season, that is, from January to May.

Traces of a vanished civilization had already given rise to the belief that the history of Brazil, like that of Mexico and Peru, extended far into remote ages, when, in 1845, the discovery in the interior of the country of the ruins of a large and very ancient city, with magnificent buildings bearing inscriptions in unknown characters, confirmed this opinion.

Nevertheless, the known history of Brazil dates only from the end of the fifteenth century. It was discovered in February, 1499, by Vicente Yañez Pinzon, a companion of Columbus. The following year it was annexed to Portugal by Pedro Al-

vares Cabral, but the new territory received little attention from the Portuguese monarchs until 1531, when an attempt at colonization was made. Shortly afterward a sugar mill was erected in São Vicente Piratininga, now São Paulo, and as the soil and climate of that part of the country were well adapted to cane culture, the industry grew and other factories were built. In 1580 there were 120 mills, the greater number being in Bahia and Pernambuco. That same year Philip II of Spain usurped the crown of Portugal, and Brazil, with the rest of the Portuguese possessions, came under Spanish rule. Under the new régime she was exposed to attack by powerful foes. Dutch forces occupied Bahia in 1624, only to be expelled by the Spaniards a year later; in 1629, however, they obtained a foothold in Pernambuco. They took Olinda and its port, but were unable to extend their influence beyond the borders of the town until the arrival of the newly appointed governor, Count John Maurice of Nassau-Siegen, in 1636. This able executive carried the Dutch dominion along the coast from the mouth of the São Francisco to Maranhão, and an expedition sent out by him captured Angola and São Thomé on the west African coast, thus securing a supply of negro slaves, while depriving the enemy of them. He did much to build up the sugar industry, so severely crippled by the war, and when in 1644 he resigned his post, the importance of Brazil as a sugar-producing country had been re-established. The Portuguese threw off the yoke of Spain in 1640 and immediately set about to retake their former colony, Brazil. After years of fighting, the Dutch were finally overcome and in 1655 a government decree drove them from the country. This banishment deprived Brazil of the Dutch sugar planters, with their slaves, their capital, their practical knowledge and skill. From the time of their exodus the Brazilian sugar industry began to decline. The greater number of these refugees established themselves in the West Indies,

where they again engaged in sugar planting with marked success.

Brazil became an independent power in 1825 as an empire, with Dom Pedro I, son of the Portuguese king, on the throne. This monarch abdicated in 1831 in favor of the five-year-old heir apparent, who took the name of Dom Pedro II and reigned until 1889, when the empire gave way to a republic. The wars carried on by Brazil against her neighbors between 1851 and 1870 brought her provinces into touch with each other, as well as with the outside world.

In 1826 she pledged herself to Great Britain that, beginning with 1830, she would suppress the traffic in African negro slaves. This promise, however, she failed to keep, so the British parliament passed an act directing the seizure of all slave ships found in Brazilian waters. In every instance the slaves were liberated and the slave dealers brought before British tribunals. Complete suppression of the importation of slaves was the result. In 1871 children born of slave parents were declared free by law, and the movement in favor of emancipation continued until 1888, when slavery was entirely abolished without any indemnity to the slave owners.

The long reign of Dom Pedro II was marked by progress and prosperity. The emperor had the best interests of his people always at heart and concerned himself more with economic development than with political activities. Broad and liberal in his views, he made no attempt to prevent the spread of socialistic doctrines, which, about the year 1880, began to seriously affect the thought of the educated classes. The feeling of unrest and the desire for change engendered in this way culminated in the military conspiracy of 1889, and, as was only natural, the former slave owners, smarting under their losses, took sides against the emperor. The monarchy fell and was replaced by a republican form of government, which, despite

several attempts to restore the empire, has endured to the present day.

In the sugar-growing regions of the north and center methods of cultivation do not show much improvement over the practice of early times. Cane is planted in holes about nine inches deep and five feet apart, no fertilizer being used. Some five weeks later the soil is turned up and after fifteen months' growth the cane matures. In São Paulo, however, the planters work on more scientific lines, and ploughing, furrowing, tilling, fertilizing and weeding are done in a thorough manner. The crop depends upon rainfall entirely, and in a normal season ripens in from fourteen to sixteen months. As soon as the cane is cut the dry cane leaves are burned and ploughing begins. The plough passes close enough to the cane roots to tear them more or less, thus helping the new growth. Shortly after the new cane shoots appear, the ground is spaded up or ploughed, just as in the case of plant cane. Ratoons ripen in twelve or fourteen months, and as a rule four to six ratoon crops are grown before replanting is done.

The yield of cane varies with the rainfall and the richness of the soil, and ranges from 20 to 30 tons per acre for first ratoons, diminishing with succeeding crops. The sugar content frequently reaches 18 per cent.

Cane is grown either by colonos or by indentured laborers. In the colono system a tract of land from 9 to 36 acres in size and planted to cane is assigned by the estate to a group of colonos according to their number. The colonos care for the cane during its period of growth and harvest it when ripe. For this they receive the equivalent of $12.50 American gold per acre. Assuming that the yield per acre is 20 tons, the cost to the owner of the estate of cultivating and harvesting a ton of cane is 62½ cents. The colono is given pasture land for his cattle, fuel and house rent free.

The indentured laborers are allotted a certain amount of untilled ground, which they prepare, plant and cultivate. Seed cane, houses and pasturage are furnished gratis, and when the cane is ripe they harvest it. The amount paid the indentured laborers for cane raised in this way fluctuates according to the market value of sugar. For example, in São Paulo when the price of sugar is $4.41 gold per hundredweight, the laborer gets $2.23 per ton for his cane; when the price exceeds $4.41 and is less than $5.90 per hundredweight, he receives $2.55 per ton; when sugar sells between $5.90 and $8.60 per hundredweight, his share is $3.18 per ton; should the price go over $8.60, he gets $3.82 per ton.

The practice in Bahia is somewhat different. Taking as a basis a price of $2.939 gold per hundredweight for sugar, the cane brings $1.646 per long ton, and for every .147 cent (1-7 cent) per pound fluctuation in the price of sugar, the value of cane changes 9.88 cents per ton up or down as the case may be.[1]

In the small factories the methods of manufacture are very old-fashioned. The cane is crushed between rolls of hard wood, and the juice, after being strained to remove the suspended impurities, is boiled to grain in copper kettles. The magma is then run into large wooden moulds having cone-shaped, perforated bottoms. The holes in the bottom of these moulds are closed when the hot massecuite is dumped in, but as soon as it cools the plugs are taken out and the molasses allowed to drain off. A layer of very wet clay is then spread over the top of the sugar, and as the water slowly drains from the clay it passes through the sugar crystals, carrying the mother liquor with it. After this washing process has gone on for some time, the sugar is removed from the moulds, and the upper portion is found to be white, or nearly so, while underneath the color deepens into yellow and from that to brown as the bottom is reached. The sug-

[1] These figures based upon Brazilian milreis, paper, being worth 1s. 4d. stg.

SUGAR PLANTATION BETWEEN RIO DE JANEIRO AND SAO PAULO, BRAZIL

ars are carefully separated according to their color, then dried and packed in bags containing 60 kilograms or about 132 pounds each.

It will readily be seen that the loss in extraction by such means is very great. In fact, from cane having a sugar content of 15 per cent, sometimes not more than between 5 per cent and 6 per cent of sugar is recovered. The best results are naturally obtained in the large factories, or usines, but even there, owing to poor crushing, 9 per cent of the weight of the cane in sugar is considered satisfactory.

In the usines the juices are treated with sulphur and neutralized with lime. They are then allowed to settle, after which they are boiled to grain and the crystals separated from the mother liquor in centrifugal machines. The sugar is dried and the remaining liquor is returned to the pans for reboiling.

The various grades produced are:

| | |
|---|---|
| Cristaes blancos | (white washed sugar) |
| Cristaes amarellos | (first yellow, termed Demerara) |
| Mascavinhos | (second yellow, fine grain) |
| Mascavos | (dark brown sugar, final product) |

The greater portion of the sugars made in Brazil is refined, but a certain amount goes directly into consumption in its raw state. Refining on a large scale according to European methods has been tried at various times, but, owing to the high cost of labor, fuel and transportation, all these attempts have proved unsuccessful. Then again, the demand for sugar prepared in the European way is not great, the Brazilians preferring the moist fine-grained sugar made in the small refineries. This sugar has a molasses taste, polarizes about 91 degrees and carries about 2 per cent of glucose. In manufacturing the white grade, a liquor of 31 degrees Baumé[1] is first made from raw

[1] A sugar solution of 31 degrees Baumé contains 56.2 per cent sucrose.

sugar. This is clarified with ox-blood and filtered through bone-char, after which the clear liquor is boiled at a temperature of 266 degrees Fahrenheit over an open fire until only about 4 per cent of water remains. It is then removed from the fire, a small quantity of dry granulated sugar is added and the mass is stirred with a wooden paddle. Cool, dry, fine-grained sugar is the result. The yellow grade, or *terzira,* as it is called, is made in exactly the same manner, except that no clarifying or filtering is done. The rich molasses odor and taste of this sugar please the popular palate to such an extent that it commands a higher price than white granulated sugar refined by the most modern processes. In fact nearly 75 per cent of the sugar consumed in Rio de Janeiro is terzira. Its manufacture does not require expensive equipment or any great amount of technical skill, hence it appeals to the native merchants and confectioners.

Recently the government has put forth some effort to encourage and improve the sugar industry, but so far without much success. A law was passed in 1875 guaranteeing a return of 7 per cent upon the money expended in constructing central factories, a given number being allowed each state. This act was modified some years later and the rate of interest reduced to 6 per cent, but as the refunding period was longer it met with more favor than the first and a number of concessions were granted. In 1889 the state of Pernambuco appropriated a sum equal to $135,000.00 gold to be divided among forty factories, with the understanding that repayment was to be begun after the harvesting of the third crop and extended over a period of twenty years. All this legislation had no definite result.

A few years ago, a combination of the producers was formed for the purpose of maintaining a high price for domestic sugar by setting aside a certain fixed amount for export. At first this was 20 per cent, but it was afterward increased to 40 per cent.

The plan, however, was ineffectual. A heavy import duty (about 5.86 cents per pound) prohibits the bringing in of foreign sugars, so that Brazil must provide for her requirements within her own borders.

Accurate information concerning production, distribution and prices is hard to obtain. Bad transportation facilities, diversity of customs regulations between the states, and the vast number of small producers who sell to the consumer direct, make the compilation of dependable data almost an impossibility. The statistics that are submitted, therefore, are approximative.

Brazil's sugar exports grow less and less. The United States no longer depends upon her for supplies, so that the outlook for the industry in Brazil is not bright at the present time. Modern refining methods are not regarded with favor by the people and any considerable extension in production seems remote.

PRODUCTION IN BRAZIL

| | | | |
|---|---|---|---|
| 1891 | 185,000 tons | 1904 | 197,000 tons |
| 1892 | 200,000 " | 1905 | 195,000 " |
| 1893 | 275,000 " | 1906 | 275,000 " |
| 1894 | 275,000 " | 1907 | 215,000 " |
| 1895 | 225,000 " | 1908 | 180,000 " |
| 1896 | 210,000 " | 1909 | 248,000 " |
| 1897 | 205,000 " | 1910 | 253,000 " |
| 1898 | 151,500 " | 1911 | 287,000 " |
| 1899 | 175,000 " | 1912 | 235,000 " |
| 1900 | 256,460 " | 1913 | 204,000 " |
| 1901 | 312,957 " | 1914 | 203,394 " |
| 1902 | 254,693 " | 1915 | 240,000 " |
| 1903 | 187,500 " | 1916 | 194,000 " |

# BRITISH GUIANA

GUIANA, in its widest meaning, is the name given to that part of South America that lies between 8 degrees 40 minutes north and 3 degrees 30 minutes south latitude and 50 degrees and 68 degrees 30 minutes west longitude. This vast territory, about 690,000 square miles in area, comprises Venezuelan Guiana, British Guiana, Dutch Guiana (Surinam), French Guiana (Cayenne), and Brazilian Guiana. The first of these divisions is now part of Venezuela and the last is included in Brazil.

The coast of British Guiana is fringed by low, alluvial flats, the result of deposit by the rivers. Beginning at three feet below high-water mark, these flats extend inland 25 or 30 miles, rising imperceptibly about 15 feet. Beyond is a broad, rolling region of sandy clay formation, 150 feet above sea-level, which runs back to the forest-covered hills. Two ranges of mountains traverse the country from west to east and a third chain forms the southern boundary and the watershed between the Essequibo and the Amazon. The highest mountain peak is Roraima on the western border, 8635 feet.

The rivers of British Guiana and their tributaries form a network of waterways throughout the country and they are practically the only transportation routes from the coast into the interior. The most important are the Essequibo, the Demerara, the Berbice and the Corentyn. The Essequibo has its source in the Acari mountains near the equator at 850 feet above the sea, and it flows north about 600 miles, reaching the Atlantic by an estuary 15 miles wide, in which there are a number of large and fertile islands. At one time sugar cane was grown on four

of these islands, but today only one, Wakenaam, has a sugar mill.

For the ten months beginning with October and ending in July, the temperature on the coast is even, as the northeast trade winds keep it down to 80 degrees Fahrenheit on an average, but the cessation of the trades in August and September makes the heat oppressive. Hurricanes are unknown and but little damage is caused in the coast regions by earthquakes, owing to the character of the soil. In the interior the year is divided into one wet and one dry season, but in the low-lying coast country, where the sugar plantations are, there are two wet and two dry periods. The long wet season begins about the middle of April and lasts until August; the long dry period is from September to the end of November. The rainfall varies greatly according to locality; on the coast the yearly average is 80 inches. In 1914 the population was estimated to be 304,089; of these 120,000 were negroes, 124,000 East Indians, 11,600 Portuguese, 4300 Europeans of other nationalities, 6500 aborigines and over 30,000 of mixed race.

Guiana was sighted by Columbus in 1498 and by Alonzo de Ojeda and Amerigo Vespucci in the year following. Vicente Yañez Pinzon is credited with having sailed up some of the rivers in 1500 and Sir Walter Raleigh ascended the Orinoco in 1595 in quest of the mythical city El Dorado. Dutch traders reached Guiana in 1598 and by 1613 they had established several settlements on the coast of Demerara and Essequibo. Meanwhile English and French adventurers were endeavoring to obtain a foothold in Surinam and Cayenne, which they succeeded in doing in 1652. The colony of Essequibo was under the administration of the Dutch West India company from 1621 until 1791, when the company was dissolved. A Dutch settlement established on the Berbice river in 1624 was the beginning of the colony of that name, which was taken under the protec-

tion of the States-general of Holland in 1732. Demerara, formerly a dependency of Essequibo, became a separate colony in 1773. In 1781 the three colonies, Essequibo, Demerara and Berbice, were captured by British privateers. The following year they were taken by France, and restored to Holland in 1783. The British took possession a second time in 1796, retaining them for about six years, at the end of which period they passed back into the hands of Holland once more. The British occupied them in 1803 and they were formally ceded to Great Britain in 1815. The three colonies were consolidated into one under the name of British Guiana in 1831.

Essequibo, Berbice and Demerara all produced a considerable amount of sugar during the Dutch régime. The plantations were on coast and river lands that had been diked and drained. Like all sugar-growing countries, this colony was adversely affected by the abolition of slavery, but owing to the success that attended the introduction of coolies from Hindustan, the labor situation never became so acute as it did in many islands of the West Indies. Traffic in African negro slaves was forbidden in 1808. After 1834 the sugar planters sought free laborers in the neighboring islands and in Madeira. Many people who had been deprived of their means of livelihood by the destruction of the vineyards of Madeira by disease settled in British Guiana. The importation of free negroes from British African possessions was sanctioned by the home government in 1840, and between that year and 1865 a large number of slaves taken by British war ships from Cuban and Brazilian slavers were landed in British Guiana, where they found employment as free laborers. This source of labor supply was cut off by the abolition of slavery in Brazil and other countries. In 1867 the importation of free blacks from British Africa was prohibited and the movement to supply laborers from China came to an end. The Chinese experiment was repeated in 1874 and 1878, but never

since. The bringing in of British Indians, however, proved a success ever since the time it was first done in 1838. These laborers are indentured for five years, and five years after the expiration of their contract they have the privilege of being taken back to their homes, without charge. During the five years following their contract term they can obtain work as free hands and they may acquire small parcels of land. In fact many of them have become land owners and have settled permanently in the colony. There are also a considerable number who, after having gone back to India, return to British Guiana of their own volition and at their own expense to work as free laborers.

Most of the sugar plantations are found on the seacoast on lands formerly marshy that have been diked and drained either by sluices or by pumping. The plantations along the river banks, too, are on reclaimed lands that have been drained by sluices. In 1911 there were 160,000 acres of reclaimed land in the colony, and 81,000 acres of it were devoted to sugar cane. The plantations are oblong in shape, one end fronting on the sea or the river, as the case may be. Originally they varied in size from 500 to 1000 acres, but in many instances consolidation has taken place. The dike next to the sea is naturally the strongest and most carefully built, while those at the sides and rear are less substantial. As a rule, there is a broad road that runs through the middle of the plantation, with a navigable canal on either side. These canals contain fresh water, salt water and flood waters being kept out by a gate through which excess fresh water may run off at low tide. Short feeder canals run at right angles, and as they are not connected with the drainage canals they may contain salt water if necessary. In crossing a transportation canal, the waters of drainage canals pass underneath through a siphon. Between these transportation canals are the cane fields, from ten to twenty acres in size, and

separated from one another by small drainage ditches. The largest transportation canals are between sixteen and twenty feet wide at the top, between twelve and sixteen feet wide at the bottom and four to five feet deep. The smaller transportation canals are twelve feet wide at the top, nine feet wide at the bottom and four to five feet deep. The large drainage canals are fifteen feet wide and four feet deep, and the irrigation ditches are from two to three feet wide and three feet deep.

Before planting cane in virgin soil the trees are cut down, the ground is cleared of grass and weeds, canals are dug, furrows are made at intervals of from six to seven feet, and then the planting is done. A month later weeds are removed, the young shoots are banked and the ground between the furrows is loosened. When five months old the cane is trashed[1] and weeding is done if necessary. After an interval of three months this operation is repeated, and when the cane is a year old the final trashing is done, the harvesting following two weeks afterward.

When the cane has been cut, the ground is loosened once more, the dry leaves are put in the spaces between the furrows and covered with earth, the young cane shoots come up, and in another year the ratoons are ready for harvesting. Two or three ratoon crops are grown on the same land, but as soon as the yield gets too small the ground is left fallow and planting is done elsewhere. Until recently Bourbon cane was the only variety raised in British Guiana. Of late, however, many kinds of seedling cane have been introduced, and today it is estimated that more than one-half of the crop comes from seedling stock. Fertilizing is done with phosphates, guano, potash, sulphate of ammonia and stable manure.

The cane is brought from the fields to the mills by canal in flat-bottomed boats. The equipment in the factories is good, as a

[1] Trashing is the stripping of dried leaves from the cane.

whole; crushing is efficiently done and the juices are boiled to grain in vacuum pans.

In addition to 96-degree centrifugals and second sugars, the celebrated "Demerara crystals" are produced. In making the latter the juice is kept acid throughout the process, from one to five per cent being lost through inversion. Chloride of tin is added in the vacuum pan to heighten the yellow color. The greater part of the molasses goes into the manufacture of rum, and a certain quantity, mixed with ground bagasse, finds a market in England as cattle food.

While on virgin soil the yield of cane runs as high as sixty to seventy tons to the acre, the average is about twenty tons per acre, and the extraction of sugar equals 8½ per cent of the weight of the cane. In late years the number of sugar mills has grown less, owing to the merging of many small plants into a few large ones. In 1908 the area planted in cane was 73,471 acres, and there were forty-two plantations, six of them less than 1000 acres, twenty-five over 1000 acres, six over 2000 acres, four over 3000 acres, and one over 7000 acres in size.

Over half of the sugar exported goes to Canada, the remainder being taken by Great Britain and the United States.

As to the future of British Guiana's sugar industry, early in 1915 a letter was sent by the government secretary of the colony to the West India committee in London in which it is stated that the possible annual crop on suitable sugar lands eastward of the Pomeroon river is not less than 1,000,000 tons, while, if the large virgin alluvial areas to the east of the Pomeroon river and between there and the Venezuelan boundary were brought under cultivation, the maximum total output might reach 2,500,000 tons per annum. This letter was in reply to a communication addressed by the West India committee to the governors of all of the British sugar-growing possessions for the purpose of securing information regarding the possibilities

of development of the industry. Hitherto the United Kingdom has been largely dependent upon foreign countries for its sugar supply, and the movement thus set on foot by the West India committee is to urge upon the home government the importance of drawing the entire sugar requirements of the country from its colonies. This of course would mean the establishment of a preferential tariff.

Exports from British Guiana since 1895, in tons of 2240 pounds:

| | | | |
|---|---|---|---|
| 1895-96 | 101,059 | 1905-06 | 121,693 |
| 1896-97 | 107,073 | 1906-07 | 120,334 |
| 1897-98 | 100,839 | 1907-08 | 99,737 |
| 1898-99 | 96,648 | 1908-09 | 117,176 |
| 1899-00 | 84,783 | 1909-10 | 101,843 |
| 1900-01 | 94,745 | 1910-11 | 108,297 |
| 1901-02 | 105,694 | 1911-12 | 83,294 |
| 1902-03 | 120,127 | 1912-13 | 83,922 |
| 1903-04 | 125,949 | 1913-14 | 103,774 |
| 1904-05 | 101,278 | 1914-15 | 113,632 |
| 1915-16 | 110,000[1] | | |

[1] Estimated.

TRAIN-LOAD OF CANE EN ROUTE TO THE INGENIO LA MENDIETA, ARGENTINA

UNLOADING A CAR OF CANE, TUCUMÁN, ARGENTINA

# ARGENTINA

THE Argentine republic occupies the southeastern extremity of South America, and extends from 21 degrees 55 minutes to 55 degrees 2 minutes south latitude, and from 53 degrees 40 minutes to 73 degrees 17 minutes west longitude. From north to south its length is 2285 miles, and its greatest width is 930 miles. Its area is 1,135,840[1] square miles, and the population, including the nomadic peoples, numbers about 8,000,000.

Physically, the surface of the country comprises three great divisions: the Andes and the high plateaus to the west, the vast plains of the east and the desolate, barren wastes of Patagonia. Only the northern part lies within the latitudes where sugar cane can be grown, and owing to the mountainous character of that region the area available for cane culture is limited. The provinces of Tucumán, Jujuy, Salta, Santa Fé and Corrientes, and the territories of Formosa, Chaco and Missiones produce the entire sugar crop.

Argentina's great length and the range of altitude within her borders, from the lofty, snow-clad peaks of the Andes eastward to sea-level, give a widely varied climate, upon which the prevailing winds and the mountain barriers exert a further influence. In the extreme north there is a stretch of country extending about ninety miles into the torrid zone and running from the Pilcomayo river, five hundred miles west, to the Chilean border. The eastern part of this region consists of a low, wooded plain where the mean annual temperature is 73 degrees Fahrenheit and the average annual rainfall is 63 inches. The west-

[1] *Century Atlas*—A recent private report (1915) gives 1,856,254 sq. miles.

ern end is a dry plateau where the temperature drops below 57 degrees Fahrenheit and the rainfall is only about two inches during the year. In the cane-growing district the rainy season is from October to March. At times during the winter the frost is severe enough to partially wither the cane leaves, but it never wholly kills the cane.

Sugar cane was brought to the La Plata region by the Jesuits, and it appears in the records of the Santo Domingo monastery that sugar was manufactured in Tucumán as early as 1670. After the banishment of the Jesuits nearly one hundred years later, the industry quickly declined, in fact as late as 1871 the total production of Argentina did not exceed 1000 tons. Development in Tucumán followed the completion of the railway, which opened outside markets to the planters of the province in 1876. Railway transportation facilities brought in modern factory equipment and machinery. As a result numerous small primitive mills were eliminated and their owners turned to sugar-cane growing.

Stimulated by a heavy protective tariff, the cane-producing area in Tucumán increased from 12,000 to 104,000 acres between 1881 and 1896, and in other provinces the industry made substantial progress. By 1894 the output exceeded the country's requirements. This led the government to concede an export bounty in 1896, and a syndicate called the Unión Azucarera was formed by the producers, who agreed to deliver to it 60 per cent of their product. From 1896 to 1904 exports of sugar varied from 15,000 to 50,000 tons per annum. Conditions changed, however. The other South American countries would not buy Argentine sugar, the United States had fixed a countervailing duty on all bounty-fed sugars, and Great Britain was contemplating their exclusion entirely. To save the situation, therefore, it was decided to curtail the output, and the following plan was adopted:

BATTERY OF BOILERS, INGENIO LA TRINIDAD, TUCUMÁN, ARGENTINA

HOME OF SUPERINTENDENT OF A SUGAR PLANTATION, TUCUMÁN, ARGENTINA

An arbitrary amount was fixed as the total production of the factories in operation, and this tonnage was prorated among them according to their capacity. Upon every 100 kilograms (220.46 lbs.) produced in excess of the allotment, a tax equivalent to 48¾ cents[1] was levied, and factories where operations were not started until after the passage of the law were taxed at this rate upon 25 per cent of their output. The fund raised in this way furnished the compensation for the growers who destroyed their cane crops or left them unharvested. A certain sum was applied to the payment of export bounty[2] and the remainder went into the national treasury.

The Brussels convention, by its provision for countervailing duties, nullified the effect of the export bounty and in 1905 the export privileges were withdrawn.

In 1912 the import duty was established at 3.85 cents gold per pound for 96-degree sugars and 2.977 cents per pound for sugars testing under 96 degrees. A yearly reduction of about one-tenth of a cent per pound was provided for until the rate of 96-degree sugars shall reach 3.0645 cents per pound, and that for those under 96 degrees 2.19 cents. Countervailing duties were also imposed on foreign bounty-fed sugars.

Tucumán produces between 80 per cent and 85 per cent of Argentina's total crop, the remainder coming largely from Jujuy.

From the "Boletin Mensual de Estadistica Agricola," Buenos Aires, August, 1913, the following figures are taken:

| PROVINCES | NO. OF FACTORIES | RAW SUGAR TONS | YIELD PER CENT |
|---|---|---|---|
| Tucumán | 28 | 121,551 | 6.8 |
| Salta | 1 | 1,290 | 8.9 |
| Jujuy | 3 | 20,052 | 7.9 |

[1] All figures given in dollars and cents are United States money.

[2] 16 centavos, paper, per kilogram, or 7¼ cents per pound.

| PROVINCES | NO. OF FACTORIES | RAW SUGAR TONS | YIELD PER CENT |
|---|---|---|---|
| Chaco | 3 | 2,762 | 5.9 |
| Formosa | 1 | 231 | 6.0 |
| Santa Fé | 2 | 838 | 6.3 |
| Corrientes | 1 | 525 | 6.6 |
| | 39 | 147,249 | 6.9 |

At the present time, Argentina has over 200,000 acres in sugar cane, and this area can be considerably increased. The present production about takes care of the country's needs, although a round amount of American refined sugar was imported in the latter part of 1916.

Field methods admit of great improvement. Little care is exercised in the selection of seed cane and disinfection is never practiced. Planting is done in September and October, when the rainy season sets in. Irrigation from rivers and streams is the rule; fertilizers are seldom used, and no preventive measures are adopted to combat diseases of the cane. The yield of cane per acre in poor soil is from nine to fifteen tons, in average soil from eleven to seventeen tons, while on the best lands it is eighteen tons.

Ratoon crops are raised fifteen or more years in succession without replanting, and the period between frosts is too short to admit of the cane reaching maturity.

Grinding is begun about June 1st and usually takes one hundred days, depending, naturally, upon the amount of cane to be crushed.

The factories are modern and equipped with machinery and apparatus of the latest type, but notwithstanding this the recovery of sugar is poor, owing to the quality of the cane. In 1911 the average extraction obtained by the factories of Tucumán was 7.65 per cent. A few factories make white sugar for

INGENIO NUEVA BAVIERA, TUCUMÁN, ARGENTINA

INGENIO NUEVA BAVIERA, TUCUMÁN, ARGENTINA

direct consumption, but the great part of the output consists of raw centrifugal sugar, which is subsequently refined. Most of Argentina's refined sugar is produced by the Refineria Argentina of Rosario.

Argentina's sugar industry could not live without a protective tariff, on account of the high cost of production, which even in the best factories is about 4⅓ cents gold per pound. There is no chance to build up an export business now, so, unless conditions change, the production must adjust itself to take care of the consumption and no more.

The statistics from 1906 to 1915 are in long tons:

| | PRODUCTION | IMPORTS | |
|---|---|---|---|
| | RAW | RAW | REFINED |
| 1906 | 114,426 | 646 | 1,260 |
| 1907 | 107,694 | 31,434 | 11,391 |
| 1908 | 157,845 | 10,648 | 24,271 |
| 1909 | 121,891 | 13,546 | 5,898 |
| 1910 | 146,472 | 33,542 | 22,342 |
| 1911 | 177,211 | 17,866 | 33,206 |
| 1912 | 147,731 | 18,728 | 10,866 |
| 1913 | 275,834 | 25,081 | 49,094 |
| 1914 | 330,460 | 154 | 6,250 |
| 1915 | 149,864 | 1 | 22 |

# FORMOSA

THE Japanese island of Formosa (Taiwan) lies off the coast of China, about two hundred miles north of the Philippines, between 21 degrees 45 minutes and 25 degrees 38 minutes north latitude and 120 degrees 10 minutes and 122 degrees east longitude. It is about two hundred and twenty-five miles long and narrow in shape; its width is seventy-seven miles and its total area 13,504 square miles. A range of mountains runs from north to south, and the highest peak is 13,600 feet. The mountainous region is rugged and well wooded, but in the southwestern part there is a fertile plain which is very productive. Rice, tea and sugar are grown pretty much all along the western portion of the island.

In the west, too, are found the best seaports and bays, also the most important towns. In 1905 Formosa had about 3,000,000 inhabitants, nearly all of whom were Chinese.

The climate is tropical, and at sea-level the average temperature in July, which is the hottest month, is about 72 degrees Fahrenheit, while in February, the coldest month, the mean is 51.6 degrees.

Sugar has been known in the island for a great many years. There is a record of a shipment having been made from there to the Netherlands as far back as 1622, from which time the trade was carried on until the competition of the West Indies closed the European markets to Formosan sugars. Nevertheless, the industry prospered and the production grew until during the last years of Chinese rule it amounted to something between 60,000 and 80,000 tons annually. Nearly all of this was soft brown sugar of fine grain, the remainder being a so-called white

sugar, made by purging the brown sugar crystals of their syrup.

The island was seized by Japan in 1895, but the Formosans made a stubborn resistance to the invaders, and it was not until 1898 that they were finally subdued and a stable government established by the Japanese. An insurrection broke out in 1902, but was quickly put down, and since then there has been no further trouble.

In 1895 Formosa had something near one thousand small mills, all driven by buffaloes. The product was a brown clayed sugar, similar to that made in the Philippines, and one-half of it was consumed locally, the other half going to China and Japan.

After the subjugation of Formosa in 1898, the Japanese were not immediately able to set about repairing the damage caused by the war. Two years later, however, they took up the task with characteristic energy and thoroughness, and the sugar industry soon felt the effects of the movement. In 1902 measures were passed providing for the establishment of a sugar station at Tainan and for the investigation of all questions relating to the industry. Young Japanese students were sent to Java, Hawaii and Europe to look into methods employed in the cultivation and manufacture of sugar in those countries and to determine by careful observation and study what would be best suited to Formosan conditions. Seed cane was brought in from other countries and comparisons of results obtained from the different plantings were made at an experiment station built by the government at Daimokko. Striped Tanna and Lahaina canes throve well, but they were rejected because they required an extraordinary amount of irrigation and constant care. The Rose Bamboo, on the other hand, was hardier and did not need so much water, consequently the experts at the sugar station did everything they possibly could to encourage its use.

At the same time the government offered companies starting sugar refineries a bonus of six per cent per annum for five years on the paid-up capital, or a single bonus of twenty per cent of the value of the plant and equipment. Other enterprises were supplied with machinery by the government for five years; in other words, the machinery was bought with government money and the sugar company was given five years in which to reimburse the government. Cane lands could be acquired on very favorable terms, and any planter who was willing to bind himself to raise a crop of cane for five consecutive years was supplied with fertilizer by the government, free of cost. These privileges remained open until the early part of 1911, when they were abrogated.

About the first enterprise to receive the benefit of this special legislation was the Taiwan Sugar company, incorporated in 1900 with a paid-in capital of 500,000 yen, which carried a bonus of 30,000 yen from the government. The company's intention was to buy the cane from the growers and make it into sugar for the Japanese market. The factory was ready for business by the fall of the following year, but as soon as grinding was begun the Chinese farmers manifested a decided unwillingness to furnish cane. As a consequence, the sugar company determined to grow its own cane, and after increasing its capital to 1,000,000 yen proceeded to carry out this plan. Arrangements were made to turn out 30 tons of sugar per day during the grinding period of 150 days, but the first year's results were only 1200 tons.

Two factories near Tainan owned by Chinese were started about this time at the instigation of the government, and also with its assistance. Unfortunately, the operators did not understand how to use the modern equipment furnished them by the authorities. Further trouble arose in connection with the buying of the cane and there was constant friction between

the factories and the government experts at the sugar bureau. So the venture proved far from profitable either to the factories or the industry.

The Chinese growers continued to cling tenaciously to their crude method of grinding cane in their buffalo-driven mills, instead of selling it to the factories, and they obstinately refused to plant the new and more productive variety of cane, Rose Bamboo, imported from the Hawaiian Islands by the government for seed purposes—this in spite of the fact that cane tops for planting could be obtained gratis at the sugar station, and that the substitution of the better cane entitled the farmer to free fertilizer, irrigation privileges and a money bonus.

It was plain that the government would have to take more vigorous action to save its sugar program for Formosa from complete failure, so in 1905 new regulations were framed and made public. Under these rules no one could embark in the business of manufacturing sugar without first securing the official sanction of the director of the sugar bureau. A fixed territory was assigned to the newcomer with the express understanding that no other factory could be established there and that all the cane growers in the territory were obligated to sell their cane to the factory and forbidden to send it out of the district or put it to any other use. The factory owner on his side bound himself to take all the cane grown in his district, even if the supply should be greater than his needs. In order to stimulate modern methods of manufacture, the sugar bureau prohibited the grinding of cane by the growers in their buffalo mills, except by special permission.

In certain sections of the island where there was no cane cultivation, large tracts of land might be granted outright to persons engaging in sugar raising and manufacture. In such cases the capacity of the factory and the period of operation was agreed upon in advance, and as soon as the land was

planted to cane, the title to it passed to the factory. If, however, the owners of the factory failed to act in good faith, the undertaking was declared void and the factory dismantled.

By 1911 twenty-nine large factories were in operation and nine others were being built. Every one of these establishments was new and equipped with the latest and most improved machinery.

It was officially announced in November, 1910, that no further charters authorizing the forming of new sugar companies or the extending of the operations of those already in existence would be issued, the reason given being the desire to limit the production to the requirements of Japan until such a time as an outlet could be found in the markets of the world. The measure was regarded as a temporary one.

The opposition of the native farmer to the new order of things was not overcome at once. Cane plantings decreased at first, but when the natives realized that cane paid them better than other crops, they gradually resumed cultivating it on the same scale as formerly, and the government bonus on Rose Bamboo cane helped matters still further.

As long as the manufacturers are far-seeing enough to pay the grower a fair figure for his cane, the supply will be forthcoming. Conversely, if too low a price is offered, the farmer will be driven to raise other crops, and, as the factory cannot purchase cane outside of its own district, lack of material will prevent it from running at full capacity, which means a heavy loss. So there is an excellent reason for maintaining the price of cane at a point which enables the grower to make a profit. Another potent factor, too, is that the price must receive the approval of the government. It is significant that the factories built between 1907 and 1911 have all been put up without government aid.

Irrigation in Formosa has not been developed to any extent

KOHEKIRIN MILL, FORMOSA

and the crop depends upon the rainfall. In the southern part of the island the monsoons are fairly regular and plentiful rains can be counted upon between June and September, with a dry period from November to April. In the north climatic conditions are not so good, and consequently all of the large sugar enterprises are to be found in the south. Ploughing by the natives is poorly done with wooden ploughs, but the modern plantations use steam ploughs with excellent results. Cane is planted every year and there are no ratoon crops. Grinding usually takes 150 days, beginning in November and ending in May.

The old-fashioned mills turn out a soft brown or yellowish white, open-pan sugar. The modern plants make centrifugal sugar only, practically all of which goes to Japan, although shipments have been made to China, Korea, Hong Kong and even Canada. The molasses is consumed at home.

Just how much of the open-pan brown sugar is used in Formosa itself it is impossible to determine, but Willett & Gray's figures for the crops, by years, since 1901 clearly show what strides the industry has made:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1901-02 | 48,381 | long | tons | 1909-10 | 205,000 | long | tons |
| 1902-03 | 34,769 | " | " | 1910-11 | 267,000 | " | " |
| 1903-04 | 60,650 | " | " | 1911-12 | 173,224 | " | " |
| 1904-05 | 50,276 | " | " | 1912-13 | 113,100 | " | " |
| 1905-06 | 64,190 | " | " | 1913-14 | 190,000 | " | " |
| 1906-07 | 81,448 | " | " | 1914-15 | 186,000 | " | " |
| 1907-08 | 68,450 | " | " | 1915-16 | 290,953 | " | " |
| 1908-09 | 122,000 | " | " | 1916-17 | 338,997[1] | " | " |

The crop of 1911-12 suffered severely from prolonged drought at planting time, and the typhoons of August, 1911, devastated the cane fields. The effect of this disaster was to deter the natives from planting cane the following year, and in

[1] Estimated.

consequence the production for that season was cut down more than fifty per cent.

It is obvious that the rapid development in Formosa has been brought about by the paternal policy of the government, without whose powerful aid the industry would in all probability have made but slow progress. The total of Japan's sugar consumption is about 300,000 tons per annum, and it is perhaps safe to hazard the guess that her statesmen will do everything they can in reason to encourage production in her own territory until this quantity shall have been reached.[1]

[1] Since the foregoing was written Formosa's production has passed the 300,000-ton mark, as will be seen by the table on page 281.

# JAVA

JAVA, the seat of the colonial government of the Dutch East Indies, lies in the Indian ocean south of Sumatra and Borneo, between 105 degrees 12 minutes and 114 degrees 35 minutes east longitude, and between 5 degrees 52 minutes and 8 degrees 46 minutes south latitude. It is 622 miles long and 121 miles wide at its greatest breadth, and this narrows to about 55 miles toward the middle of the island. The area of Java proper is 48,504 square miles, Madura comprises 1732 square miles and the smaller islands under Javan jurisdiction cover 1416 square miles.

Of the three general divisions of Java, the east, the middle and the west, each has certain structural features of its own. In west Java the highlands lie to the south and the lowlands to the north. Middle Java takes in the isthmus and part of the wide eastern portion. In the isthmus the mountain barrier on the south is less regular and the northern plains are broken to a certain extent. The eastern division is made up of an intricate confusion of hills and valleys, except on the south coast, where the mountain range forms a continuous barrier. The shore line of the north coast is low everywhere, with morasses, sand dunes and shifting river mouths, but it is of much greater importance than the south coast, which is steep, at intervals rocky and constantly battered by a violent surf.

Java is one of the most distinctly volcanic regions of the world—it has fourteen active volcanoes and one hundred and twenty-five recognized volcanic centers.

Both the north and south coast lines are broken by rivers, the principal ones being on the north. In the dry season they

contain little water, but during the rainy monsoon[1] they frequently become rushing torrents that burst their banks and overflow the surrounding country. Such inundations carry with them a considerable amount of disintegrated volcanic rock, part of which is deposited on the plains and swept seaward. In this manner the alluvial plains near the river courses are formed and the shoals in the harbors and at the river mouths as well.

Java enjoys a comparatively even temperature the year round. Ninety-six degrees Fahrenheit was recorded in Batavia in 1877 and that is the highest mark known. The lowest was 66 degrees Fahrenheit, which was experienced in the same place in the same year. The mean annual temperature is 79 degrees Fahrenheit, and the difference between the warmest and the coldest months is 1.8 degrees Fahrenheit. The year is divided into two seasons by the prevailing winds—the rainy period, that of the wet monsoon, from November to March, and the dry period the remainder of the year, when the dry monsoon blows. There is no long unbroken rainfall and no long spell of drought. The average rainfall is much greater on the south coast than on the north: in Batavia it is 72.28 inches yearly, while Majalenka has an annual fall of 175 inches. Windstorms are rare and hardly ever cyclonic, but thunderstorms are of frequent occurrence. Under an almost vertical sun, the day is of nearly uniform length throughout the year.

The plains vary in fertility according to their geological formation, but with the exception of the regions abounding in marshes, stretches of disintegrated coral, and lakes, they are tillable and productive.

Sugar cane was brought to Java by the Chinese or Hindus in very remote times. The Chinese pilgrim Fa Hien mentions having found sugar there when he visited the island in 424,[2] and as trading was constantly carried on between Arabia, India,

[1] Asiatic trade wind. [2] Geerligs.

China and Java, there is but little doubt that when the secret of boiling the sugar juice to a grain was discovered it became known to all of them at once.

About 1520 the Portuguese established trade relations with the natives and early in the seventeenth century the Dutch influence began to make itself felt. The Dutch East India company built forts and set up trading stations in the coast towns; at first it acquired only small pieces of land in Jakatra (Batavia) and it was some time before its holdings were increased. Finally Jakatra was conquered and the Dutch power in Java firmly established. But little was done at the outset to help the sugar industry, as the policy of the Dutch East India company was to foster trade in the products of the East rather than undertake to raise any of the commodities itself. The sugars that were sent by it to the mother country at the beginning of its operations, therefore, came from China, Formosa, Siam and Bengal, and no Javan sugars reached Holland until after 1637, in which year the company decided to establish sugar mills on its own-land near Batavia.

It also parceled out land to Chinese sugar growers and granted them special concessions in consideration of the entire product of the land being sold to the company at an agreed figure. Prices and terms changed from year to year, however, and much confusion and dissatisfaction resulted. War, cane pests, cattle diseases and labor troubles still further complicated the situation. In 1648 the company's plantations produced 124 tons and in 1652 the outturn was 723 tons. The increase in West Indian production hurt the Javan factories and the war in Bantam in 1660 stopped development. In 1652, twenty mills were running, but in 1660 half of the number had closed. Peace with Bantam was concluded in 1684 and matters then began to improve. By 1710, one hundred and thirty mills were in operation and the industry was extended to Bantam,

Cheribon and Japara. The policy of the company, however, was to restrict production so as to keep up prices, and to this end it prohibited the erection of any new mills and limited the output of those that were running to eighteen tons per annum each, thus fixing a maximum total of 2340 tons. This amount was not realized, however, as the number of factories decreased until in 1745 only sixty-five were in operation in the territory near Batavia. The company then decided to raise the number to seventy, and five years later it added ten more. As years went on the number of factories diminished, but their capacity increased, and in 1779 fifty-five mills furnished 6176 tons of sugar to the company.

The Dutch East India company was dissolved in 1795 and the Dutch interests in Java passed under the control of the Batavian republic,[1] afterward the kingdom of Holland, which was brought under French rule when Holland fell into the hands of Napoleon. In 1811 it was seized by England and was finally restored to Holland in 1816.

All this time the regulations governing the sugar industry were being constantly changed. The producers had always been at loggerheads with the company, for while they were bound to deliver their entire output to the company, it did not consider itself obligated to take delivery of any definite amount. This left the planters in a very unsatisfactory position, as they could never look ahead with any degree of certainty. At length a law was passed in 1797 calling upon the factories near Batavia to produce 2810 short tons yearly for the government, with the privilege to them to dispose of any sugars made in excess of this amount for their own account. A similar law affecting the factories on the north and east coasts was proposed. In this territory there were thirty-one factories in 1794 with a capacity of 1000 tons, which quantity it was proposed to increase to 2000

[1] Formed by France out of the Netherlands in 1795. It existed until 1806.

tons for delivery to the government and 500 tons for sales for account of the producers. In furtherance of this plan, the mill owners were to be granted tracts of new cane land and the government was to make cash advances up to 50 per cent of the estimated value of the growing crop. These propositions were never carried into effect, and a production of 1000 tons per annum remained the maximum for that section of the country.

In the vicinity of Batavia, however, the measure was a success, especially as the government encouraged the manufacturers by increased advances and by supporting prices. The result was that during the early years of the nineteenth century the production grew, but a sharp decline came in 1811-13, and in the latter year the total production of Java fell to about 600 tons.

The causes were not hard to find. Holland was dominated by France and sea traffic was blocked by the British, so that Java had to keep her sugar in storage at home. Nevertheless, the government continued to encourage the production in the hope of an early peace and so that the industry might not die out. Each year, therefore, added to the government's stocks of sugar until the amount became burdensome for financial reasons, and the traditional policy of the government was abandoned. Manufacturers were allowed to dispose of their sugars freely and without restriction, but unfortunately the privilege was granted at a time when it was impossible to sell and the British occupation of Java did not mend matters.

When Java was restored to Holland in 1816, the new government continued the freedom of the industry, but it had received so severe a check that to revive it was a difficult matter. In 1826 the output was 1220 tons, and in this year the authorities renewed the system of making advances and stimulated growth and manufacture, so that in 1830 the production had increased to 6700 tons.

That same year a new governor-general, van den Bosch, was appointed. He was entrusted with the task of making the island a producer of the commodities required by the mother country and was given a free hand as to the means to be employed in accomplishing his purpose. The plan he put into effect was known as the "Cultural System" and its principal features were as follows:

In the districts adapted to sugar cultivation, the natives were to contribute one-third of their arable land to be planted in cane as required. The natives were to till the fields, supply fuel and cattle for ploughing and transportation, and in consideration of this they were exempted from the free service due from them by law to the state. Payment for labor was to be made out of the proceeds of the crops after deducting the land tax.

The crushing of the cane and its manufacture into sugar was done under contract by private individuals who were assisted by government money in the building of factories. The contractors turned over the sugar to the government at a fixed rate, at the same time repaying the money advanced to them.

At the outset there was next to no profit for either the government or the producers, in fact the first few years showed an actual loss, so that it became a hard matter to induce anyone to undertake the manufacture of sugar on a contract basis. This led to a modification of the regulations and the manufacturers were permitted to sell a part of their output on their own account. In this way their interest was stimulated and there was a change for the better, attended by a profit both for the producer and the state. By 1870 the government, recognizing that the sugar industry was established on a sound footing, decided to withdraw from any participation in the manufacture and a new set of rules was formulated, under which the government's direct connection with the industry was confined to the growing of the cane. The government then had to dispose of a por-

tion of the land and the native labor at a just figure, and when once the cane crop was turned over to the contractor he had to take care of any further field work, together with the harvesting and transportation of the cane, out of his own funds without government help. Commencing with the year 1879, the government was to reduce its interest in the original contract plantations one-thirteenth annually, so that government participation in both cultivation and manufacture of sugar should terminate by 1891. It was stipulated that the manufacturers could make whatever disposition of their output they wished, and in lieu of rent for the land they planted to cane, they were to pay a fixed price for the cane, and in addition a premium based on the yield of the years 1864-69. On privately owned plantations the government exacted a tax of $10.00 for every 1.74 acres. This tax on privately grown cane was abolished in 1886 in order to stimulate the then languishing industry, and the premium on state plantations was cut down one-half between 1887 and 1891, with the proviso that the payment of the other half should be deferred until 1892-96.

Unfortunately for the producers in Java, there was a disastrous slump in sugar prices just about the time these new measures were formulated. The tremendous output of beet sugar sent the price below cost in 1882-84, and besides this a strange disease, called *sereh,* worked havoc with the cane in the fields and caused serious loss. This disease made its appearance in western Java in 1884 and spread rapidly, affecting the production everywhere. After carrying on a hard but losing fight for some years, the sugar men summoned science to their aid in this difficulty. H. C. Prinsen Geerligs was called to Java in 1891 and three experimental stations were established to fight the sereh. Through the efforts of the officials in charge of the experiment stations, specimens of cane were brought from all parts of the cane-producing world, the object being to find a

cane that would be as rich in sugar as the Black Cheribon (the most popular variety then grown in Java) and yet able to withstand the sereh. Fresh healthy cane was planted for seed purposes in the mountains, far from the disease-infected region, and much care was taken in the way of disinfection and quarantine precaution to prevent the sereh from spreading into the sections that were free from it. These measures were accompanied by exhaustive scientific experiment work to find out the cause and the nature of the disease and how it could be overcome.

These stations not only accomplished the purpose for which they were built, but they were of great benefit to the industry in all of its branches. As a result, planting, growing and manufacturing methods have been vastly improved, chemical control of factories has been introduced and economic scientific methods govern every department of the work. By these means, supported by the addition of fresh capital, the sugar industry of Java was not only saved from extinction, but was lifted into a very prominent world's place, and for years past Java has furnished an example of remarkable efficiency and low cost of production.

Java's sugar plantations are situated in the eastern and central part of the island. The surface of much of the western end is broken and mountainous, lacking uninterrupted stretches of level land suitable for agriculture, and presenting obstacles to transportation. The great drawback, however, even in the vast plain of Krawang, is climatic. As has been said, the ideal climate for sugar cane is one that combines abundant rain during the period of growth with an uninterrupted dry season to ripen the cane and admit of its being readily harvested and transported to the mill. In west Java these conditions do not obtain, as the wet and dry seasons are not sharply defined.

The plains along the north central coast, east of the river

Tjimanoek, between the sea and the foothills are, with the exception of a few open stretches, devoted to cane growing. There is also a considerable area in cane south of the central chain of mountains.

In east Java the sugar estates are found in the wide valley of the river Brantas, on the plateaus of the provinces of Madioen and Kediri, in the fertile plains along the north coast and in the lowlands bordering upon the Bali strait.

In 1912 Java had 184 sugar factories in operation, divided among the various residencies as follows:

| RESIDENCY | FACTORIES | ACREAGE IN CANE | SUGAR PRODUCED TONS OF 2240 LBS. |
|---|---|---|---|
| Cheribon | 12 | 22,346 | 85,728 |
| Pekalongan | 15 | 29,847 | 124,322 |
| Samarang | 12 | 22,490 | 97,462 |
| Banjoemas | 5 | 18,640 | 82,142 |
| Kedoe | 2 | | |
| Djokjakarta | 18 | 27,785 | 120,384 |
| Soerakarta | 16 | 24,122 | 97,706 |
| Madioen | 6 | 13,376 | 47,463 |
| Kediri | 20 | 48,005 | 195,232 |
| Sourabaya | 38 | 65,633 | 275,920 |
| Pasoeroean | 29 | 57,684 | 199,390 |
| Bezoeki | 11 | 16,763 | 58,493 |
| Total | 184 | 346,691 | 1,384,242 |

While these figures show the acreage actually under cane, the total amount of land used in the production of the crop is much greater. It takes over twelve months for the cane to mature, and as some fields are being cut others are being planted. The ground required for factory buildings, dwellings, roads and other purposes connected with the industry must also be taken into account, and it has been estimated that altogether

1,200,000 acres are tributary to cane culture. The annual plantings cover about 350,000 acres and the portion of the remainder that is not devoted to roads, buildings and so forth is sown with other crops or allowed to lie fallow for a time.

The general plan of crop rotation on an average is:

| | |
|---|---|
| First year | May-October, sugar-cane crop is cut. |
| " " | October-November, soya beans, maize, etc. |
| " " | November-April, rice. |
| Second year | April-November, indigo, tobacco, beans, fallow. |
| " " | November-April, rice. |
| Third year | April until May-October of the fourth year, sugar-cane crop. |

Sometimes tapioca is planted instead of rice immediately after the cane crop is harvested, but cane invariably follows a rice crop. The European planter confines his operations to sugar cane, and the other products are raised by the native farmer exclusively by his own efforts and on his own account.

The terms under which plantation land is held in Java differ widely from those that govern in other cane-growing countries. Between 1830 and 1879, when the compulsory cultural plan was in effect, the government determined what lands were to be planted in cane. It compelled the natives to cultivate and harvest the crop, but allowed them compensation for their labor and the use of their fields. The wages thus paid were ultimately accounted for when the sugar was sold by the government. Each district, or group of districts, delivered the cane product to the mill agreed upon and the grinding was done under a contract with the government.

When, at a later period, the sugar estates had to produce their own cane, they gradually took over the land on a rental basis and grew cane upon it by paid native labor. In 1879, when cultivation was free, the government factories had 7531 acres

leased from the natives, in addition to 64,470 acres of cane that they ground under contract with the government. At this time the independent factories had 16,824 acres rented and were growing cane upon it under their own management and for their own account.

During the gradual abolition of the cultural system, the fields first given up by the government were those situated at a considerable distance from the factories and those to which it was difficult to bring water for irrigation. It came about naturally that when the factories had the selecting of the lands they were to rent, they picked out the best in their neighborhood for their purposes. In this way an exchange of the tilled fields was effected. Subsequently, estates were extended and new tracts of land occupied, but in increasing the acreage, each factory was careful to confine its operations to its own district and thus avoid competing with other factories in renting new ground. The old-established factories already had their acreage, and when the compulsory cultivation plan was abandoned, they mutually agreed upon the territory in which each factory should rent land without interference on the part of any of the others. Whenever a new plantation was established, its district was clearly defined, so it will be seen that under this plan there could be no competitive bidding on land rents. There have been instances of newcomers having disregarded this convention, but in every case they have sooner or later acknowledged their error, and today there is perfect harmony among the factors as to the territory in which each interest rents its land.

In Java, cane is almost always grown on lands irrigated by the same means that are employed in irrigating rice, the privilege of using these works being included in the rent of the land. Under the compulsory régime it was the rule that in the dry season irrigation water should be utilized for the cane fields during the day and for native agriculture during the night, and

this regulation remained effective after the withdrawal of the government from the industry.

As the water supply was controlled by private enterprises, it frequently happened that in a time of scarcity it was not impartially distributed. After 1890, when the acreage of the cane plantations was being constantly extended, the authorities found themselves obliged to prevent encroachment by the cane growers on the land required to produce the necessities of life for the natives, and also to see to it that the new extensions of cane land should not be allowed to appropriate an undue proportion of the available water to the detriment of both the established plantations and the native agriculture. Accordingly, in 1894, legislation touching the renting of land and the use of water was begun, the principal features being as follows:

All new sugar enterprises, or any addition to an existing enterprise, to apply to the director of the civil service for his sanction of the undertaking, and the applicant to declare the maximum area of land to be planted with cane each year, as well as the names of the districts in which it is desired to rent cane lands.

The authorities investigate conditions in order to determine whether or not the proposed increase will conform to the rules governing the "Lease under contract with the native population." They are also careful to satisfy themselves that the granting of the request will not produce unfair disparity between the amount of land and water used for cane cultivation and that devoted to the raising of foods for the natives.

The permit to rent the necessary amount of ground provides that, while the length of the lease may vary according to conditions, the land cannot be held by the sugar factory any longer than is necessary to grow and harvest one crop of cane. This takes between fifteen and seventeen months, and the land must be in the hands of the native farmer directly before and after

that period. Leases to be valid must be drawn up before a civil-service official and have his approval.

No permits for the establishment of new factories or the extension of existing enterprises will be issued for the time being in districts where important changes in the irrigating system, either new construction or additions, are contemplated. As a rule, the period during which the natives are prohibited from renting lands that have been opened up to irrigation for the first time is fixed at five years. This is done in order to afford the natives an opportunity to realize what the land is worth before leasing it. The amount of water to be used in the growing of rice and other crops as well as cane has also been clearly agreed upon and great care is taken to see that full justice is done to all concerned.

As the water brought by canal is not sufficient to irrigate the entire cane acreage, the government has allowed the factories to install a number of large pumping plants by which water is raised from rivers. In such cases, whenever the factories have pumped water enough for their own requirements, they are generally willing to operate the pump free of cost to supply water to the native farmer.

In the principalities or semi-independent states of Java, where the native princes have made grants of land to their nobles as appanage, another rental system prevails. Both princes and nobles lease large tracts of land for long periods to European agriculturists, and such leases include not only the fertile portion with the irrigation facilities and the water, but the rocky, barren spaces as well. Here the tenant has to make the most of the possibilities of the property and determine what part of it is best suited for cane culture and what part for other purposes.

Besides the two plans of tenure just described, certain lands are held under absolute title or perpetual lease. Over a hundred

years ago large tracts were sold outright at times, the title carrying all the seignioral rights, and consequently the owners are free to plant and irrigate without restriction. In later years European farmers were no longer permitted to purchase, but much jungle land was leased for seventy-five-year periods. Such leases were made for the most part in mountainous or sparsely settled territory, and as sugar culture thrives best in the low plains where labor is plentiful, sugar has not been benefited as much by the long-term leases as have tea and cinchona bark. Still there are sugar plantations that hold land under perpetual lease with unrestricted rights and water for irrigation.

Plantations situated in the thickly populated lowlands have no trouble in securing labor, but it is another matter in districts that have been newly opened up or on perpetual-lease holdings where the population is small. In the last two cases labor must be brought in from other districts, and sometimes there is difficulty in doing this, especially during the rice harvest or when large public works are under construction.

However, such conditions are unusual, and, as compared with other sugar-producing countries, Java is in a peculiarly fortunate position with respect to a steady supply of good labor at low cost. All of the arduous work is done by men, but women cut cane tops, plant seed and do watering and weeding, while children are employed in destroying insects and other light work.

In April or May, as soon as the rice crop has been cut, the field is prepared for planting sugar cane. The soil is first drained of its superfluous moisture, and, if the ground be loose, it is generally ploughed several times. Heavy soils, instead of being ploughed, are treated by the Reynoso method. This consists of digging deep ditches to carry off the subsoil water and to supply irrigation water later on. The plot is then divided by cross ditches into pieces about one-sixth of an acre in size and


SUGAR CANE AFFECTED BY THE SEREH, JAVA

SEEDLING CANES, JAVA

finally the furrows for the seed are dug. These furrows are generally thirty feet long, from twelve to eighteen inches wide, twelve or fifteen inches deep and four or five feet apart. The earth displaced in digging is piled up between the furrows. Thus prepared, the field is left exposed to wind and sun for about six weeks and at the end of this period the heavy wet clods have crumbled into a gray or light-brown powder. During the drying-out process the grass has to be removed repeatedly, and in case of rain, the soil that is washed down into the furrows is thrown back upon the ridges to prevent the furrows from silting up. The hard bottom of the furrow is loosened or square holes are dug in it and filled with loose soil. Part of the earth on the ridges is thrown into the furrow and the field is then ready for planting.

Before the outbreak of the sereh, seed for new plantations was obtained exclusively from tops of ripe cane, but when the disease became prevalent, it was found that cuttings taken from sereh-infected cane gave diseased yields, while cuttings from cane grown in districts not affected by the sereh produced cane that did not suffer so greatly from the disease. At the beginning of the trouble, cuttings from outside healthy districts were used, but as the disease spread, the demand for sound cuttings increased while the sources of supply became fewer. Finally, plantations were established in remote districts free from disease and they were carefully quarantined. Here seedlings were grown from young cane cut at full length, and in this way sound seed was obtainable at all times. Formerly, seed was only to be had in the grinding season, which frequently occasioned delays in planting. The new plan not only enabled the cane growers to stamp out the sereh, but even after the disease had been practically eradicated it was continued because of its manifest advantages.

Seedlings used for planting are cut into lengths, each having

three eyes. Unhealthy stalks and any showing the presence of insect pests or fungi are culled, while the sound pieces are carefully disinfected. The seed thus prepared is placed horizontally in the furrows end-to-end and covered with earth. At first water is applied at four- or five-day intervals, afterward less frequently, until the cane has attained a considerable height. About this time the rainy monsoon sets in and further irrigation is not needed. The stalks are banked several times during the early period of growth and fertilizing accompanies the second and third banking. Until comparatively recently the fertilizer consisted of nitrogenous substances, while potash and phosphoric acid were considered of no value. The first investigations concerning fertilizers were made on rich lands that had been irrigated with river water when the wet rice crop was being grown, and the water brought with it sufficient potash and phosphates for the needs of the cane. In such cases it was shown that adding these substances to the soil was unnecessary and that nitrogen was the only element that could increase the yield of cane. Hence groundnut cakes and sulphate of ammonia were used almost entirely. It has been proved, however, by more thorough study that much ground is low in phosphates, and this fertilizer has been added with excellent results. As regards potash, the soil of Java seems to contain sufficient for cane cultivation.

When the cane leaves become sufficiently thick to shade the ground the weeds die. Borers, beetle larvae and termites are caught during the early growing period, but all labor stops with the last banking and the advent of the wet monsoon. When the wet season is over, the cane is trashed and samples of the growing cane are taken from the fields and tested in the laboratory of the factory to determine the degree of ripeness. As soon as the roads become dry enough to admit of cane-laden carts passing over them, the harvesting of the ripest cane begins.

The cane is dug up by the roots, care being taken to leave as little as possible of the roots in the ground. The roots and the earth adhering to them are removed, together with the leaves and tops, and the clean cane is loaded on cars to be taken to the mill.

Formerly carts drawn by oxen and buffaloes were used to transport the cane to the factory, but the crop has grown to such proportions that cattle-drawn carts have had to give way to the rail. Today nearly every plantation has its own railroad with permanent and portable tracks, over which the cane moves in cars hauled by cattle or locomotives.

Having been unloaded at the mill, the cane is taken to the crushers on carriers. Three sets of rolls are generally used and water is sprayed on the cane before the last crushing, after which the bagasse is fed to the furnaces as fuel. The juice is strained to free it from fragments of cane and leaves, then milk of lime is added and heat applied. The heavy impurities settle at the bottom, the clear juice is drawn off and the remaining juice is separated from the foreign matter in the filter presses. Another method is to treat the juice at a low temperature with a large admixture of milk of lime, and afterward with carbonic acid or sulphurous acid until all the lime is neutralized. Then all the juice is clarified by filtration without the settling operation. Next follow evaporation, refiltering, boiling to grain and separation of the crystals from the mother liquor in centrifugal machines.

In 1903 the Java manufacturers began to make a bid for the British Indian trade. After some experimenting they succeeded in producing an almost-white raw sugar, which at once found favor in India, where sugar refined by the bone-char process was objected to for religious reasons. Statistics compiled for the year 1912 show that this so-called "Java white" represented 39.2 per cent of the entire output; 26.2 per cent was muscavado,

29.9 per cent European assortment and 4.7 per cent second sugars.

Java, with her population of more than thirty millions, presents altogether different conditions to the sugar grower than other cane-producing countries. A large proportion of the agricultural area is needed for crops of food to nourish the inhabitants. The land available for sugar cane is rented at an equitable figure and, as has been said, there is always an ample supply of cheap and readily obtainable labor. The aim of the Javan planter is to produce cane carrying a high sugar content and to get as great a yield as possible. To this end, unceasing attention is paid to cultivation, fertilizing and the general well-being of the crop; in other words, the soil is worked for all there is in it.

While the scientists of the country are absorbed in the task of producing through cross-culture new species of cane that will give a heavier yield per acre with a higher sugar content and greater purity, the agriculturists are opening up extensive fresh tracts of rice and cane land. New irrigation projects play an important part in this development and everything points to a steady growth of the industry.

The following table shows the annual output since 1840 in tons of 2240 pounds:

| | | | |
|---|---|---|---|
| 1840 | 46,296 | 1850 | 85,153 |
| 1841 | 45,176 | 1851 | 118,443 |
| 1842 | 50,320 | 1852 | 74,806 |
| 1843 | 55,544 | 1853 | 109,961 |
| 1844 | 62,419 | 1854 | 110,323 |
| 1845 | 89,526 | 1855 | 102,321 |
| 1846 | 86,263 | 1856 | 123,124 |
| 1847 | 81,431 | 1857 | 104,479 |
| 1848 | 88,512 | 1858 | 130,725 |
| 1849 | 103,445 | 1859 | 131,571 |

| | | | |
|---|---|---|---|
| 1860 | 134,001 | 1888 | 349,719 |
| 1861 | 134,726 | 1889 | 327,735 |
| 1862 | 142,755 | 1890 | 393,680 |
| 1863 | 129,716 | 1891 | 400,372 |
| 1864 | 138,009 | 1892 | 415,332 |
| 1865 | 135,714 | 1893 | 472,082 |
| 1866 | 140,042 | 1894 | 522,574 |
| 1867 | 130,947 | 1895 | 572,381 |
| 1868 | 175,960 | 1896 | 525,947 |
| 1869 | 179,579 | 1897 | 577,036 |
| 1870 | 150,184 | 1898 | 713,575 |
| 1871 | 187,851 | 1899 | 750,400 |
| 1872 | 205,992 | 1900 | 732,498 |
| 1873 | 195,924 | 1901 | 791,046 |
| 1874 | 198,318 | 1902 | 882,966 |
| 1875 | 190,576 | 1903 | 929,880 |
| 1876 | 234,111 | 1904 | 1,038,373 |
| 1877 | 241,930 | 1905 | 1,022,759 |
| 1878 | 221,140 | 1906 | 1,050,926 |
| 1879 | 229,616 | 1907 | 1,191,007 |
| 1880 | 212,763 | 1908 | 1,222,262 |
| 1881 | 274,796 | 1909 | 1,227,553 |
| 1882 | 287,392 | 1910 | 1,258,222 |
| 1883 | 319,574 | 1911 | 1,443,397 |
| 1884 | 388,019 | 1912 | 1,331,180 |
| 1885 | 374,041 | 1913 | 1,345,230 |
| 1886 | 350,397 | 1914 | 1,303,045 |
| 1887 | 369,847 | 1915 | 1,264,000 |
| | 1916 | 1,500,000[1] | |

[1] Estimated.

# AUSTRALIA

THE island-continent of Australia lies south of Asia, between the Indian and Pacific oceans, and it extends from 10 degrees 41 minutes to 39 degrees 8 minutes south latitude and from 113 degrees to 153 degrees 30 minutes east longitude. Its area is 2,974,581 square miles and the population, not including aborigines, is 4,455,005, mainly of British origin.

Dutch and Spanish explorers visited Australia in 1606. On April 19, 1770, its eastern coast was first sighted by Cook, who, nine days later, dropped anchor in Botany bay. Sailing north, he touched at several points, and after having completed a survey of the east coast, he took possession of the territory between 38 degrees south and 10 degrees 30 minutes south. He reached Australia again in 1772 and in 1777 he landed on the coasts of Tasmania and New Zealand. The first settlement was established at Port Jackson in 1788 and gold was discovered in 1851. The commonwealth of Australia comprises the following political divisions: Victoria, New South Wales, Queensland, South Australia, Northern Territory, Western Australia and Tasmania.

As over 90 per cent of Australia's sugar crop comes from Queensland, this article will deal with the growth and condition of the industry in that state only. Queensland has an area of 668,497 square miles, of which 920,010 acres were under cultivation in 1913; of this, 147,743 acres were planted with sugar cane.

About one-half of Queensland lies in the tropics and the remaining area stretches southward to the twenty-ninth par-

CUTTING CANE, MAROOCHY RIVER, SOUTH QUEENSLAND

CARTING CANE TO MILL, INGHAM DISTRICT, NORTH QUEENSLAND

allel. The temperature is affected in a marked degree by the breezes that blow steadily from the sea and moderate what otherwise would be excessive heat. It is warmer along the coast than in the uplands of the interior, and in the northern part the heat is very trying to people who have come from temperate climes. At Rockhampton the winter temperature averages 65 degrees Fahrenheit, and in summer the mean is nearly 85 degrees. The annual rainfall on the seacoast is large, particularly in the north, where it ranges between 60 and 70 inches. At Brisbane it is about 47 inches, while a large part of the interior receives from 20 to 30 inches, but it falls below 20 inches in the west and south. There are no active volcanoes in Australia and no violent earthquakes have occurred in recent years.

The sugar plantations of Queensland are found in a strip of territory running along the eastern coast between the sixteenth parallel and the southern border. This stretch of land has been divided into three districts, the southern, the central and the northern, the last being the most important, as it furnishes over 60 per cent of the total sugar production of the state.

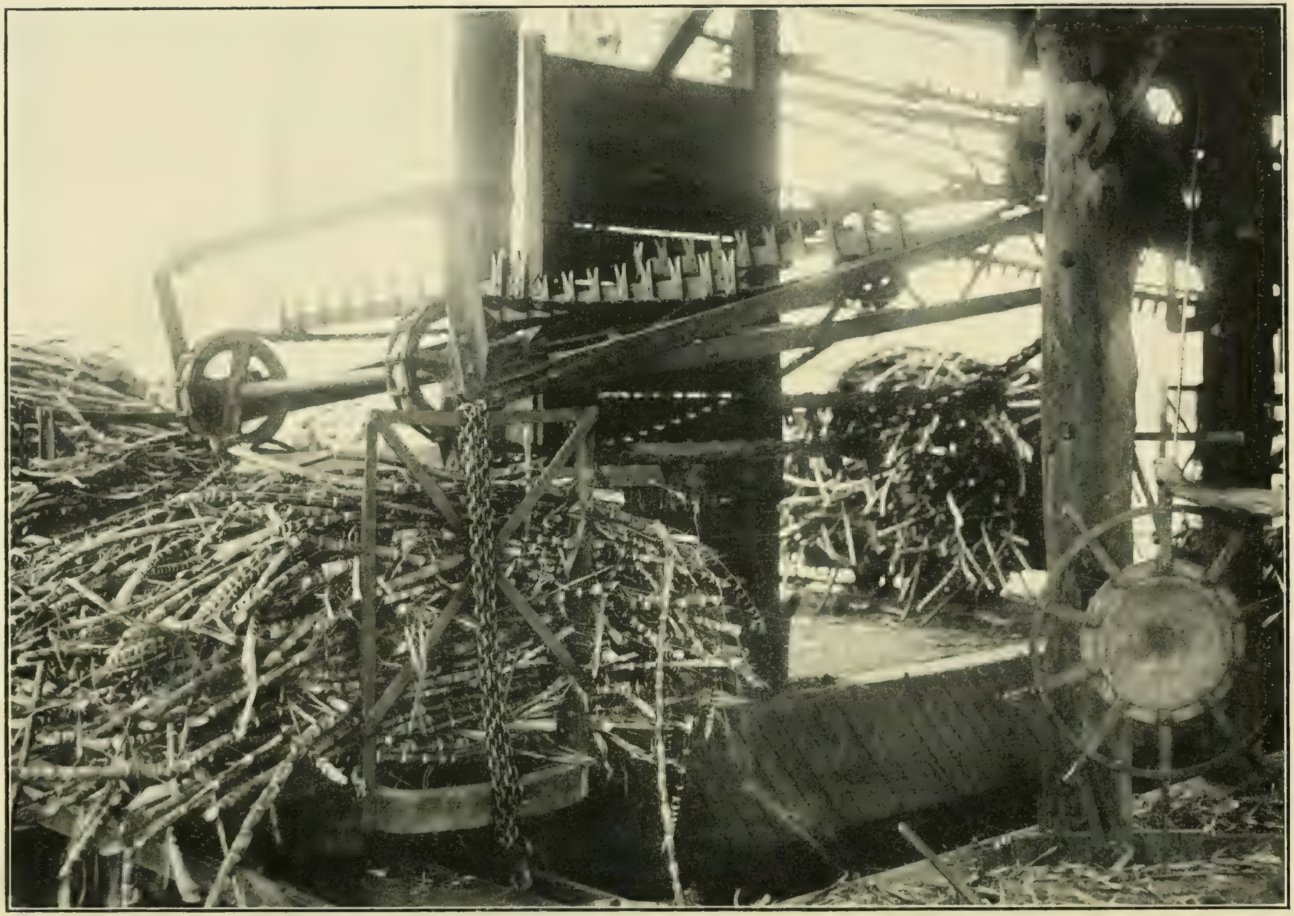
The cane lands are of two kinds—scrub land and forest land. The scrub lands may be divided into two classes, *true scrub* and *bastard scrub,* the former being characterized by a dense, almost impenetrable vine growth and timber of soft wood. In the bastard scrub there are both hard and soft woods, the former predominating, and very little vine growth is met with. The soil of true scrub lands is of two kinds, alluvial and volcanic. The alluvial soil is composed of clay, fine sand, gravel and vegetable and mineral matter brought from the high levels by water action. The soil of forest lands is diversified and, for sugar-cane culture, "blady grassed" bloodwood country with a porous subsoil is selected. Here the yield of cane per acre is

not so heavy as on scrub lands, but the sugar content of the juice is greater.

The growth of sugar cane and the manufacture of sugar in Australia date back to 1823, but no substantial progress was made for a number of years. The first cane to be raised in Queensland was grown in the botanic gardens in Brisbane in 1847 and sugar was first manufactured in that state in 1862. The following year Captain Louis Hope had twenty acres in cane on a plantation near Brisbane and to him is due the credit of establishing the sugar industry in Queensland. In 1867 there were nearly 2000 acres in cane and six mills in operation, while the next year saw 5000 acres planted, with twenty-eight mills at work. The industry grew and throve until 1875, when the cane crop was almost completely destroyed by a disease known as "rust," which was really due to imperfect cultivation, lack of proper drainage and the soft variety of the cane. As over 60 per cent of the estates were being operated with borrowed capital, the planters found themselves in serious financial trouble and many mortgages were foreclosed. Up to this time Bourbon cane was the variety generally grown, and when the disease wrought such havoc with the crop, it was noticed that the Rappoe cane did not suffer from rust. The hardiness of this variety encouraged the growers to substitute it and other sturdy species of cane for the Bourbon. The change proved entirely successful and the planters enjoyed good times once more.

The sugar industry of Queensland was carried on at the outset under the plantation system, that is to say, the planter, besides growing the cane, owned the mill and manufactured the sugar. This method worked very well until 1884, when a period of extreme depression came in the wake of the great boom that began in 1879. In 1885 the industry appeared to be in danger of extinction, and, as a remedial measure, the legisla-

ISIS CENTRAL MILL, CHILDERS, SOUTH QUEENSLAND



CANE UNLOADER, MULGRAVE CENTRAL SUGAR MILL, CAIRNS DISTRICT, NORTH QUEENSLAND

tive assembly voted £50,000 for the establishing of central factories. Two mills were operated on the new plan as an experiment with such marked success that an act was passed in 1893 to foster the development of the central-factory system. The act enabled a number of planters to form a co-operative company for the purpose of building and equipping a central mill. The necessary funds were obtained from the government, the cane lands being pledged as security for the loan, and the mills erected by this means became the property of the companies upon the payment of the loan. The large estates were gradually cut up into tracts of from fifty to one hundred acres each and were leased or sold on reasonable terms; in this way the land was settled by a large number of farmers.

Nevertheless, there was grave danger that the benefit accomplished by this new law would be more than offset by the "white labor" agitation. As is well known, the labor party is very strong in Australia, and probably no other branch of agriculture in that country has been so beset with labor troubles as the sugar industry. For nearly thirty years the supply of laborers for the cane fields was drawn from the South Sea islands and India, principally the former. The white laborers were loud and insistent in their protests against the employment of Kanakas, as the islanders were called, and finally, after the formation of the commonwealth in 1900, an act excluding colored labor entirely and providing for the deportation of the Kanakas to their homes was passed by the federal government. To afford the planter relief for the hardship worked upon him by this measure by reason of the high wages they had to pay in order to secure white laborers, a duty was placed upon foreign sugar. A bounty upon sugar produced by white labor was also provided for, but this, together with the excise tax on sugar, was abolished in 1913. Today the industry is protected by a customs tariff of one and three-tenth cents per pound.

When cane is to be planted in new ground, the scrub, stumps and logs are first cleared away and the field is then ready for the seed. Holes are made with a mattock at regular intervals, the seed cane is placed therein, covered with earth and left to grow. The ground is hoed from time to time to keep the weeds under control, but the young cane does not require much attention after the first five or six months. On cleared land, ploughing is done two, three or four times, after which the surface is harrowed, rolled and planted. Three or four weedings are necessary during the growth of the crop.

From Mackay northward planting is done between February and October, but in certain low-lying districts in the north May, June and July are not considered good months for planting on account of the possibility of frosts. The cane ripens in from twelve to eighteen months. In the region south of the tropic line, planting is done early, although much cane is set out in August and September. The cane when cut is transported to the mills by narrow-gauge railroads, some of these lines being portable. In the north crushing begins in June and ends in December, while in the south the greater part of it is done from August to December. From two to four crops of ratoons are raised, but usually not more than three, the land lying fallow for one season. Fertilizing is not generally practiced, although some growers make use of legumes or dry manures as enrichers. The former consist of the Mauritius bean, the cow-pea and vetches, which are ploughed into the land after they have attained a certain growth.

Under ordinary conditions the rainfall is so evenly distributed in the sugar-growing districts that irrigation is not needed. Still, there are places where it has been found necessary to irrigate freely, owing to the amount of rain being insufficient for the crop needs. In such cases, wherever practicable, water is obtained by damming rivers and streams and

is distributed over the cane fields through ditches by gravity. Where, however, the topography of the country does not admit of this being done, pumping is resorted to and large stations have been established for this purpose. The yield of sugar per acre since 1894 has been 1.688 tons and the amount of sugar extracted since 1904 averaged 10.95 per cent of the weight of the cane.

The federal government maintains an experiment station at Mackay and experiment farms have been laid out in the important sugar centers. The value of the work done at this station cannot be too highly estimated. The scientists in charge are constantly on the lookout for new varieties of cane and are on the alert to fight diseases and pests. The chief enemies of the cane in Queensland are cane grub, fungus pest, frosts and floods.

Today Queensland has forty-eight sugar mills and two refineries. Thirteen of the mills are centrals and four of these are under state control. Additional factories are under construction.

Most of these plants are equipped with three sets of rollers and modern machinery, the capacity ranging from 70 to 960 tons of cane per day.

The annual production of sugar in Queensland since 1894 in long tons has been as follows:

| | | | |
|---|---|---|---|
| 1894-95 | 91,712 | 1902-03 | 77,835 |
| 1895-96 | 86,255 | 1903-04 | 89,862 |
| 1896-97 | 109,774 | 1904-05 | 145,020 |
| 1897-98 | 97,916 | 1905-06 | 152,259 |
| 1898-99 | 163,734 | 1906-07 | 182,188 |
| 1899-00 | 123,289 | 1907-08 | 185,063 |
| 1900-01 | 92,554 | 1908-09 | 150,400 |
| 1901-02 | 120,858 | 1909-10 | 132,816 |

| | | | |
|---|---|---|---|
| 1910-11 | 207,340 | 1913-14 | 255,000 |
| 1911-12 | 176,076 | 1914-15 | 246,408 |
| 1912-13 | 113,060 | 1915-16 | 150,000 |
| | 1916-17 | 200,000[1] | |

[1] Estimated.

# MAURITIUS

GREAT BRITAIN'S island colony, Mauritius, lies in the Indian ocean between 57 degrees 18 minutes east and 57 degrees 49 minutes east, and 19 degrees 58 minutes and 20 degrees 32 minutes south, 550 miles from Madagascar. Irregular in shape, it extends 36 miles from north-northeast to south-southwest, and its greatest width is 23 miles. Its area is 710 square miles.

Mauritius is of volcanic origin, although signs of volcanic activity no longer exist. It is encircled by a coral reef which is submerged at high tide. The central part of the island is a tableland that rises from 500 to 2700 feet above sea-level and occupies more than half of the total surface. In the north and northeastern coast regions there are extensive low plains, but the rest of the coast territory is more or less broken by hills. The registrar-general's report for 1908 gives the population as 374,450.

The climate is agreeable during the cool season, but oppressively hot in summer, which begins in December and ends in March. The temperature falls from April to June and rises again from June to December. In the elevated inland plains of the interior the thermometer ranges from 70 to 80 degrees Fahrenheit in summer, and in Port Louis and the coast region it runs from 90 to 96 degrees during that season. The average temperature at Port Louis is 78.6 degrees Fahrenheit throughout the year.

The rainfall varies greatly in different parts, but an average of ten years (1893-1902) gave 79 inches for the entire island. Cyclones are frequent and generally occur between December and April.

The soil consists chiefly of a very light clay formation, easily penetrated by water. In some localities the clay is deep and evenly deposited, while in others many large pieces of lava are found in it, so that ploughing is impossible.

Mauritius was discovered by the Portuguese in 1505. From 1598 to 1710 it was in the hands of the Dutch, and in 1715 it was taken by France, from whom it was wrested by the British in 1810.

The Dutch brought sugar cane from Java to Mauritius in 1650, but their efforts at cultivation were not successful.

When in 1741 de la Bourdonnais was appointed administrator of Mauritius, or, as it was then called, l'Ile de France, it was a crown colony under the control of the French East India company. The island was without agriculture or commerce and the inhabitants were sunk in indolence. The genius of the new executive brought order out of chaos, and his example and assistance aroused the people from their lethargy. Sugar cane was again imported in 1747 and in 1750 a sugar estate was established at Pamplemousses in the northern part of the island by de la Villebague, the governor's brother. The industry expanded and was carried on with profit.

In 1769 an experiment station was established with a view to furnishing planters with the knowledge of which they were so sorely in need. Agricultural development, however, was not carried forward to any great extent while Mauritius remained under French rule. State interference with the planters had an unfortunate effect, and besides this the greater number of the inhabitants looked upon the colony not as a permanent home, but as a means to acquire sufficient money to enable them to return to France and live there in comfort. The authorities deemed it essential that the colony should produce the greater part of its foodstuffs, while the planter on his side was anxious to grow crops that he believed would give him the best

results in money; for example, sugar, cotton, coffee, indigo and spices.

In 1776 there were three small sugar factories on the island, and in 1789 the production of sugar was 300 tons. Disaster overtook the industry, owing to conditions that made the cost of the mills abnormally great and the extravagance with which they were operated. In consequence many of those who built factories were ruined.

Shortly after the British occupation there was a change for the better. In 1816 the production of sugar was 4430 tons, and from that time forward the industry made continuous and steady progress. The planters were encouraged and, as far as could be, helped in their operations, while the policy of the government developed the colony's resources and established for it trade relations on a firm basis with other countries.

The method of extraction of sugar from the cane employed at the beginning of the last century was primitive indeed. The apparatus consisted of a solid, heavy table made of thick planks carefully finished and having a perfectly smooth top. It was made in the shape of a parallelogram, with a groove or gutter on each of its four sides and an opening in the middle of each end gutter. Upon this table was a huge, heavy cylinder of hard wood, slightly longer than the width of the table. Three, four, or five stalks of cane were placed lengthwise on the table and submitted to pressure by rolling the cylinder over them from one end to the other and back again. The juice thus expressed from the cane ran into the gutters at the sides and ends and through the holes into two tubs placed to receive it. The cane stalks were then removed, put in the sun to dry and afterward used as fuel in the boiling of the sugar juice. This operation was repeated until a sufficient quantity of juice was obtained.

From the tubs, or "bacs," the juice was run through a series of kettles, or open-fire caldrons, for concentration. The kettle

next in position to the bac into which the juice from the table fell was called *la grande*, because it was really the largest of the set. It was farthest from the fire and served as a defecator. As soon as the juice contained in it became heated, a thick, creamy substance formed on the surface and was immediately skimmed off. The liquor was then ladled into the second kettle, where the boiling became more lively on account of closer proximity to the furnace. The juice bubbled up in foam and at this point the cleansing process began. A long, flat piece of wood was passed slowly over the surface of the liquor, thus removing certain impurities. Here the mixture of lime begun in *la grande* was continued until the liquor was found to be perfectly clear.

Passing to the third kettle, the liquor was reduced to syrup by the increased heat. It was concentrated in the fourth and boiled to grain in the fifth. Directly under the fifth and last kettle of the set was the furnace, which was fed by bagasse and cane trash.

The boiling process finished, the sugar was removed from kettle number five and placed on tables, where it remained until it had to be taken to larger tables farther on to make room for a fresh batch. There it stood with other boilings until the following morning. Then the crystallized mass was shoveled into pots and carried to large bins constructed so that the liquor, or syrup, could drain off. This usually took from fifteen to twenty days, after which time the sugar was dug out by pick and shovel, put into baskets and taken to be spread out in the sun to dry. After two to three hours of this drying, according to the intensity of the sun's rays, the sugar was packed in a double sack containing about 135 pounds.

By such means little more than one-third of the sugar in the cane could have been recovered, and the product obtained was heavy and dark in color.

From 1816 to 1845 a change was gradually made from the

clumsy apparatus just described to three-roller vertical mills, and from wind- and water-driven mills to steam power, thus increasing the extraction. No perceptible improvement was effected in field methods during this period.

In 1852 a number of vacuum pans and centrifugal machines were in use. Some eight or ten years later the efforts made to combat the diseases of the cane began to bear fruit and the planters of the coast and inland estates started to exchange cane tops.

During the period of 1866 to 1875 single crushing was almost universal. A few factories used double crushing with maceration, but the mills were not powerful. Marked progress was made in the chemical treatment of the juice. Shortly afterward the planters began to appreciate the vital importance of chemical control in their factories and scientific principles were applied to the culture of the cane.

Up to 1835 the labor in the fields had been done by African negro slaves. The emancipation of these slaves was declared on February 1st of that year, and their final liberation took place in March, 1839. In anticipation of this, the authorities had arranged five years previously for the bringing in of a number of immigrants from India, and from that time down to the present virtually all the labor required in the cane fields has been drawn from India. In 1834 the immigrants from India numbered 75 and in 1908 the Hindu population was 263,419.

One of the most important events in connection with the growth of the sugar industry of Mauritius was the formation of the Chamber of Agriculture in 1853. This body fostered mutual co-operation and interchange of ideas among the planters. It exercised its influence in bringing about legislation affecting agricultural and industrial questions and the development of the resources of the colony. The Station Agronomique, instituted in 1893, and the Bacteriological Station in 1908, came

into being as a result of the efforts of the Chamber of Agriculture, to which credit is also due for the extension of the cane-raising area to its present proportions.

During the last hundred years the island of Mauritius has suffered from a series of disasters—epidemics of cholera, small-pox and bubonic plague, hurricanes and droughts.

In 1892 a hurricane of extraordinary violence sowed frightful devastation, destroying cane, wrecking houses and killing numbers of people. Ten years later nearly all the draft animals were carried off by *surra*, a deadly cattle disease, which made its appearance just as the largest crop on record was about to be harvested. In addition to the direct loss of horses, mules and cattle, the difficulties of transportation delayed the work of gathering and crushing the cane long after its maximum richness had been reached. The yield for the 1903 crop was thus appreciably reduced, and the growing period for the crop of the following year greatly curtailed. The shortage in 1903 has been placed at 11,000 tons, while that for 1904 amounted to 23,000 tons. These losses caused such distress that it became necessary to invoke state aid, which was provided by the Mechanical Transport loan of 1903.

All agricultural centers are subject to crises more or less serious in character, and, as has just been shown, Mauritius is no exception to the rule. Depressions resulting from crop shortages, however, should not be confounded with the general troubles that have seriously menaced the cane-sugar industry during the last half century, almost all of which are attributable to the competition of the beet. Over sixty years ago the Mauritian planters began to feel apprehensive concerning the future of their sugar trade, owing to the rivalry of beet-root sugars in the markets of Europe, and between 1870 and 1880 the prospects were indeed gloomy. What chance had the cane-sugar-growing dependencies of Great Britain against bounty-

fed beet sugars raised on the continent? If the increased production had taken place in the cane industry, the disturbance in trade conditions would have been gradually overcome by a process of natural adjustment. But unfortunately for the cane planters, the enormous extension of sugar-raising possibilities by new means in territory not hitherto available found them totally unprepared to cope successfully with this new competition.

In 1885 the Chamber of Agriculture instituted an inquiry into the causes that had brought the cane trade to such a critical state. The attention of the planters was called to the improved methods employed by the beet-sugar manufacturers and to the rapidity with which their trade was expanding. The cane growers were earnestly urged to take steps to meet the conditions that confronted them. Manifestly the cost in field and factory was too high. The task of working out the problem took considerable time and involved the outlay of vast sums of money. It was all the more difficult because of the necessity for finding new capital in the face of decreasing revenue, but it was undertaken with courage and perseverance, and the results have justified the efforts put forth and the sacrifices made.

The growers of sugar cane in Mauritius have adjusted themselves to the new conditions. They have reduced plantation and manufacturing costs, and scientific methods have enabled them to grow cane profitably on land which could not possibly have been cultivated in the old way without severe loss. Crude processes have given way to the modern sugar factory with its up-to-date roller mills, clarifiers, triple effects, vacuum pans and centrifugal machines, and the chemical engineer has changed the dark mixture of crystals and molasses into an almost pure white granulated sugar.

The crop for the season of 1915-16 amounted to 215,528 tons.

A great deal in the way of improvement in cultivation still

remains to be done, but it may be truly said that the island has fought its way into the front ranks of sugar-producing countries. With its natural advantages of climate and soil, the enormous possibilities of irrigation and development of water power, the accessibility of an unlimited supply of Asiatic labor, and the markets of India, Africa and Australia at its doors, there is ample justification of high hopes for the future.

Yearly output of sugar, exclusive of local consumption, since 1895:

| | | | |
|---|---|---|---|
| 1895 | 143,000 tons | 1906 | 220,000 tons |
| 1896 | 153,000 " | 1907 | 170,000 " |
| 1897 | 124,000 " | 1908 | 205,758 " |
| 1898 | 183,000 " | 1909 | 244,597 " |
| 1899 | 161,000 " | 1910 | 226,099 " |
| 1900 | 190,000 " | 1911 | 164,260 " |
| 1901 | 155,000 " | 1912 | 206,497 " |
| 1902 | 142,000 " | 1913 | 249,800 " |
| 1903 | 218,000 " | 1914 | 277,164 " |
| 1904 | 142,101 " | 1915 | 215,528 " |
| 1905 | 188,364 " | 1916 | 220,000[1] " |

[1] Estimated.

# NATAL

ON Christmas day, 1497, Vasco da Gama, then on a voyage to India, sighted the entrance to what is now Durban harbor, and named the country Terra Natalis.

This maritime province of the British Union of South Africa lies approximately between 27 degrees and 31 degrees south latitude and 29 degrees and 33 degrees east longitude. On the southeast it is bounded by the Indian ocean, on the southwest by the Cape province and Basutoland, on the northwest by the Orange Free State and on the north and northeast by the Transvaal and Portuguese East Africa. Its coast line is 376 miles long and its area is 35,371 square miles. It is divided into two parts, Natal proper and Zululand, the former comprising 24,910 square miles and the latter 10,461 square miles. In 1908 the population, including that of Zululand, was 1,206,386, of whom 91,443 were European, 998,264 natives and 116,679 Asiatics.

The surface of the country is of terrace formation. The coast strip south of Durban is quite narrow, but north of that point it becomes wider and more level. Ranges of hills roll back to the first plateau, which is about 2000 feet above the sea. The second plateau rises sharply between 4000 and 5000 feet and extends to the Drakensberg mountains, whose base is from 6000 to 7000 feet in elevation, and in which all the rivers of Natal, except the coast streams, have their source.

Natal's sugar plantations are situated in the low, moist regions of the coast zone, between 28 degrees and 30 degrees south latitude, *i. e.,* quite a distance below the tropic of Capricorn. The industry had its beginning in 1850, when the first

cane was brought from Mauritius. Operations did not amount to much at the outset; a limited amount of cane was ground in small mills and the juice was boiled into sugar. In 1878, however, a factory with the newest equipment of that time was erected at Mount Edgecombe by Mauritius people. Henceforward, the production of sugar in the colony has shown a steady growth, and today there are thirty-four factories in active operation with an output of about 100,000 tons of sugar per annum.

The climate of the valleys and the coast belt is hot and humid. Summer, beginning in October and ending in March, is the wet season, while May, June and July are the driest months. At Durban the temperature ranges from 42 degrees Fahrenheit in winter to 98 degrees Fahrenheit in summer, the mean being 70 degrees, and both the temperature and the humidity are affected by the Mozambique current that flows southward from the equator. The annual rainfall at Durban is about 40 inches and the average for the province is placed at 30 inches.

The kind of cane most generally grown in Natal at the present time is the *Uba,* a hard, yellow variety that was brought from Hindustan. For fertilization, stable manure, cane ash and phosphates are employed. Owing to the geographical position of the country, it takes longer than usual for the cane to ripen. Plant cane matures in two years and first and second ratoons in eighteen months for each crop. So five years' time is necessary to produce three crops, and at the end of this period replanting is done. After the cane is cut, it is loaded on railway cars for transportation to the mill. All of the raw sugar produced in Natal is refined there, except what is consumed in a raw state. In addition to the sugar made in the province, quite a little is imported from foreign countries, as Natal distributes a good deal of the commodity in adjoining states. The home industry is protected by a duty of $1.215 per 112 pounds on foreign sugar, while no duty is assessed on sugar going from one

province to another throughout the British Union of South Africa.

Formerly the most desirable laborers came from India, but recently the Indian government has stopped the exportation of natives of that country as plantation laborers, so Natal, like many other sugar-growing sections, has its labor problems.

The production in long tons since 1894 has been as follows:

| | | | |
|---|---|---|---|
| 1894 | 19,369 | 1905 | 26,158 |
| 1895 | 20,508 | 1906 | 21,479 |
| 1896 | 20,651 | 1907 | 24,223 |
| 1897 | 20,245 | 1908 | 31,999 |
| 1898 | 29,186 | 1909 | 77,491 |
| 1899 | Boer war | 1910 | 84,437 |
| 1900 | 16,689 | 1911 | 92,000 |
| 1901 | 36,662 | 1912 | 82,589 |
| 1902 | 21,095 | 1913 | 85,714 |
| 1903 | 33,944 | 1914 | 91,619 |
| 1904 | 19,238 | 1915 | 100,000 |
| | 1916 | 125,000[1] | |

[1] Estimated.

# EGYPT

EGYPT, the northeastern corner of the African continent, is bounded on the north by the Mediterranean sea, on the northeast by Palestine, on the east by the Red sea and on the west by Tripoli and the Sahara. The 22nd parallel of north latitude is the dividing line between it and the Sudan on the south. Its area is about 400,000 square miles, of which by far the greater part is desert; it has been truly said that the principal features of Egypt are the desert and the Nile.

In 1907 the entire population was 11,189,978, exclusive of nomadic Bedouin tribes, who numbered about 97,000. Of these 10,366,046 were Egyptians, 735,012 settled Bedouins, 65,162 Nubians and 221,139 foreigners—British, Italians, Turks and Greeks.

The wonderful fertility of the soil of the valley of the Nile is due to the annual inundation caused by the melting of the snows and the spring rains in the region in which the Blue Nile has its source. The turbulent waters of the swollen stream rush down the Nubian valley laden with rich loam from the mountains of Abyssinia, and this is deposited upon the flat plains on either side when the river overflows its banks. The period of high water begins in June and lasts until the end of September.

The rainfall is slight and there are years when there is none whatever. Crops, therefore, depend upon irrigation, and powerful pumping plants supply the needs of the large estates, while the small native holdings depend upon water-wheels worked by buffaloes or by the natives themselves. The irrigation possibilities of the country were greatly extended by the huge dam

constructed by the government at Assuan in 1902. In the cane-raising country, the average temperature in summer ranges between 82 degrees and 110 degrees Fahrenheit, and between 50 degrees and 86 degrees in winter. Cool nights are the rule and occasionally there is a killing frost.

Sugar was introduced in Egypt by the Moslems when they conquered the country, 640-646 A. D., and the Egyptians were quick to apply their knowledge of chemistry to its preparation. By remelting the first crystals, then treating the liquor with lime and albumen, removing the suspended impurities by filtration, boiling to grain once more and purging the crystals of their syrup by washing, they succeeded in making a sugar far superior to that produced elsewhere. The cultivation of cane prospered and the excellence of the sugar manufactured in Egypt was maintained throughout the Middle Ages, until the conquest by the Turks in 1517. Ottoman dominion ruined Egypt industrially. A little sugar cane continued to be raised and some sugar was made, but on so unimportant a scale as to be hardly deserving of mention. This state of affairs lasted until 1850, when Ismail Pasha (afterward khedive, 1863-79,) caused sugar cane to be brought from Jamaica and five years later the government took steps to foster sugar manufacture. In 1877 a change came about, through which the control of the factories passed from the hands of the khedive to a government committee, under whose auspices several new mills were constructed. In 1896 the output of sugar reached 75,000 tons. The factories operated by the government body were sold in 1903 to a French corporation, known as the "Société Générale des Sucreries d'Egypte," which some years previous had built three factories of its own. By this purchase the French company practically obtained a monopoly of the sugar business of the country. The financial crisis of 1905 proved a setback, but after the trouble arising from this had passed, the company formu-

lated plans for enlarging its plantations and grinding an increased amount of cane.

Sugar cane is grown along the Nile banks from a short distance above Cairo up to Assuan, or between 24 degrees and 30 degrees north latitude, a stretch of more than four hundred miles. In width, however, this territory is confined to the valley of the Nile, which is only twelve miles wide at the extreme and narrowing to very much less. The agricultural possibilities of the eastern or right bank are not so great as those of the left, owing to the fact that it is mountainous in many places. Consequently most of the cane and all of the sugar factories are to be found on the left (western) bank.

Ploughing is done in autumn and the ground is further prepared during the following February; the furrows are then made; shortly afterward the cane is planted, covered with earth and the water is turned in. Irrigation is kept up until the end of October, when it is discontinued for two or three weeks to allow the cane to ripen. Harvesting begins in December and lasts until April. The cane when cut is transported by camels to the railway and thence to the mill. The customary procedure is to raise one crop of plant cane, one crop of ratoons and one crop of cotton or beans in succession, allowing the land to lie fallow the fourth year, and so on every four years.

The yield of cane per acre depends upon the soil, the adequacy of the water supply and the temperature ruling during the period of growth; the average from plant cane is twenty-four tons and from ratoons sixteen tons.

The factories depend upon cane furnished by the growers, either large plantation owners or small farmers who cultivate a few acres of rented land, and one of the serious problems which they have to face is the difficulty of obtaining an adequate supply. The capacity of the factories is large, the machinery is modern and they could easily take care of a much larger

cane tonnage than they have been able to secure. An improvement is looked for as a result of more liberal terms recently offered to growers. The bulk of the output is raw centrifugal sugar, famous under the name of "Egyptian crystals," and much sought after for flavoring chewing tobacco. The vineyardists of the Champagne district in France get from Egypt the sugar used in making their sparkling wines, as they hold that cane sugar is the only kind that will not hurt the flavor of the champagne.

According to Willett & Gray the yearly crops in long tons since 1903 were:

| | | | |
|---|---|---|---|
| 1903-04 | 60,000 | 1909-10 | 52,525 |
| 1904-05 | 60,000 | 1910-11 | 49,394 |
| 1905-06 | 65,000 | 1911-12 | 57,879 |
| 1906-07 | 42,195 | 1912-13 | 75,420 |
| 1907-08 | 55,648 | 1913-14 | 69,368 |
| 1908-09 | 34,835 | 1914-15 | 75,738 |
| 1915-16 | 110,000[1] | | |

[1] Estimated.

# SPAIN

SPAIN lies in the extreme southwest of Europe and it embraces about eleven-thirteenths of the Iberian peninsula. Its total area is 194,700 square miles, and in 1914 the population numbered 19,712,585.

It is said that Phoenician traders reached there as early as the eleventh century before the Christian era. In 238 B. C., or three years after the close of the first Punic war, Hamilcar Barca, the famous Carthaginian general, crossed from Africa into Spain, taking with him his son-in-law, Hasdrubal, and his son Hannibal, both of whom were destined to play great parts in the coming struggle between Carthage and Rome. From a few trading posts, Hamilcar extended the Carthaginian dominion in Spain to that of a great province, that not only proved a source of immense revenue, but that also furnished a never-failing supply of warlike troops for the armies of Carthage. The second Punic war ended the sway of the Carthaginians in Spain, and from 201 B. C. until 406 A. D. the country was under Roman rule. Then came the barbarian invasion and the Visigothic kings, whose power was shattered in turn when the Berber Tarik defeated King Roderic in 711. For centuries afterward the struggle of reconquest went on until Granada, the only remaining Mohammedan stronghold, surrendered to Ferdinand and Isabella on January 2, 1492. That same year, under the auspices of these sovereigns, Columbus set out on his first journey westward, and with his discovery of America came a revolution in the sugar industry of the world.

Spain is the only cane-sugar-producing country in Europe. Sugar cane was brought there by the Arabs when they con-

quered Granada, and its cultivation had assumed important proportions in that kingdom at the time of the expulsion of the Moors. The introduction of the plant in America had a serious effect upon sugar production in Spain and other countries of the Old world, and over three hundred years later the Spanish growers of cane had to meet the competition of the beet sugar of central Europe. Finally the loss of her colonies in 1898 stimulated the industry in the mother country by relieving the Spanish planter from protected competition in his home market. In 1903 Spain had fifty beet-sugar factories, thirty-two cane-sugar mills, fifteen syrup mills, eleven refineries and two factories that turned out sorghum sugar and glucose. Shortly afterward, however, prices in Spain dropped below the cost of production, so that a period of profit was followed by a period of heavy loss. As a result of this state of affairs, the Sociedad General Azucarera de España was formed. This organization comprised forty-three beet factories, thirteen cane factories and thirteen other mills, and its object was to limit the number of mills in operation and to introduce greater efficiency into cultivation methods. The plan did not prove successful, and finally, after lengthy discussions between the Sociedad General, the independent producers and the government, it was decided to fix the excise tax on sugar at thirty-five pesetas per 220.4 pounds, and it was agreed that no new factory should be built within a fifty-mile radius of any factory in operation. The output of each mill was fixed every year between the owner and the government, and if this amount should be exceeded the surplus was debited to the factory for the following year.

Early in 1916 a royal decree authorized a reduction in the import duty on sugar from 60 to 25 pesetas per 100 kilograms. Since then there has been a heavy increase in imports, and the government is now being importuned to restore the tariff protection, lest the home industry be destroyed altogether.

The cultivation of sugar cane in Spain is decreasing year by year on account of competition from the beet. The area devoted to cane culture in 1913 was 9900 acres, while in 1915 it had dwindled to 4069 acres. The plantations are situated in the provinces that border on the Mediterranean coast between Gibraltar and Almeria, or, roughly speaking, between 36 and 38 degrees north latitude, a long way outside of the tropics, but where the climate is warm and free from frost nevertheless.

Three varieties of cane are grown: the white, the red and the striped, and the kind selected is determined by the nature of the soil. White cane requires a good soil with plenty of fertilization; red cane needs a deep soil carrying a large amount of moisture and also well manured. The striped cane calls for the same conditions as the red and gives about the same weight of cane per acre. The method of planting is similar with all three. A cane crop is raised every fourth year on land that has previously been planted in wheat, maize, barley or sweet potatoes. The fields are ploughed deeply in January and February and the ground is well fertilized. During March the furrows are made three and one-half feet apart, one foot deep and eight inches wide, and more manure is added when it is thought to be necessary. Sulphate of ammonia, nitrates, basic slag, fish guano and phosphates, as well as stable manure, are used for fertilizing.

Two rows of seed cane are placed in each furrow, so that the amount of seed required is large, being about 9800 pounds to the acre. The reason for this is that in the moderate climate of Malaga, Granada and Almeria the formation of secondary stalks is not certain, conseqently there must be ample provision for a sufficient number of primary stalks. As soon as the seed is planted it is covered with a layer of earth and enough water to moisten the ground effectually is turned into the furrows. These waterings are continued as often as necessary while the crop is

growing, and the cane is banked from time to time. Finally the land is leveled and the last banking done. The furrows now appear raised above the surface instead of being below it as at first. Water is turned on at the proper point and allowed to run over the entire field, and this operation is repeated every ten or fifteen days during the summer.

The crop is ready to be cut one year after planting, so that harvesting and grinding begin in March and are finished in May. As soon as the cane is cut it is stripped of its leaves and taken to the mill. Part of the leaves is utilized as straw for the cattle and the remainder is burnt. If it should be decided to follow this crop by one of ratoon cane, the spaces between the rows are then ploughed, fertilizer is added and the process of irrigation and banking is kept up until the ratoons reach maturity.

In 1910 there were thirty-four cane mills in Spain, divided into two classes: first, the *trapiche,* a small affair where the juice obtained from the little cane that is ground is made into table syrup, and, second, the *fabrica,* where white and yellow sugars and molasses are manufactured. The average fabrica is well equipped and managed. The diffusion method of extracting the juice from the cane is employed to a large extent. At the beginning of the refining process the juice is treated with sulphur and lime, after which it is clarified in the usual way. The heavy impurities are removed by bag filters and the clear juice is decolorized by filtration through bone-char. The first liquor is boiled to a fine-grained massecuite, which is purged of its mother liquor in centrifugal machines and dried in large cones[1] of white sugar, which are broken up into small pieces and used in that form. A fine white granulated sugar is boiled from the second liquor, while from the third and fourth liquors soft yellow sugars are made. The final molasses is distilled into alcohol.

[1] From 10 to 15 pounds in weight.

That the outlook for the cane-sugar industry is far from promising is evidenced by the fact that the output has fallen off from 34,548 tons in 1900 to 6,359 tons in 1915. The area available for cane culture is limited and too far from the tropics to give satisfactory crop results. Then again, a high surtax has had the effect of restricting the consumption, which at the present time is somewhere in the neighborhood of 150,000 tons per annum, all told.

As the foregoing figures show, nearly all the country's requirements are served by beet sugar, concerning which a word or two may be timely at this point.

In 1899, the year following the conclusion of the Spanish-American war, which cost Spain her colonies, the duty upon foreign sugar brought into that country was increased from fifty pesetas to eighty-five pesetas per 220.4 pounds, and the excise tax was fixed at twenty-five pesetas. This legislation effectually barred out the foreign article and at the same time stimulated the home industry. Much capital that was withdrawn from the lost colonies was invested in the culture of sugar beets and the manufacture of beet sugar. The profits realized from these operations were very large at first, which naturally led to expansion and finally overproduction.

During the year ending July 1, 1913, the total amount of beet sugar turned out was 156,892 tons. In 1914 the production amounted to 140,394 tons, representing the output of thirty-three factories. The latest information obtainable gives the number of factories as thirty-eight, and two-thirds of these are said to be controlled by the so-called "Sugar Trust of Spain."

| | PRODUCTION OF CANE SUGAR[1] | CONSUMPTION |
|---|---|---|
| 1904 | 22,175 tons | 98,043 tons |
| 1905 | 28,819 " | 107,191 " |
| 1906 | 15,722 " | 117,749 " |

[1] Willett & Gray, January 13, 1916.

| | PRODUCTION OF CANE SUGAR | CONSUMPTION |
|---|---|---|
| 1907 | 16,092 tons | 113,968 tons |
| 1908 | 14,057 " | 117,190 " |
| 1909 | 21,669 " | 104,740 " |
| 1910 | 20,301 " | 133,608 " |
| 1911 | 20,295 " | 130,769 " |
| 1912 | 16,176 " | 143,664 " |
| 1913 | 13,231 " | 143,826 " |
| 1914 | 7,376 " | 126,425 " |
| 1915 | 6,359 " | 156,618 " |

# INDIA

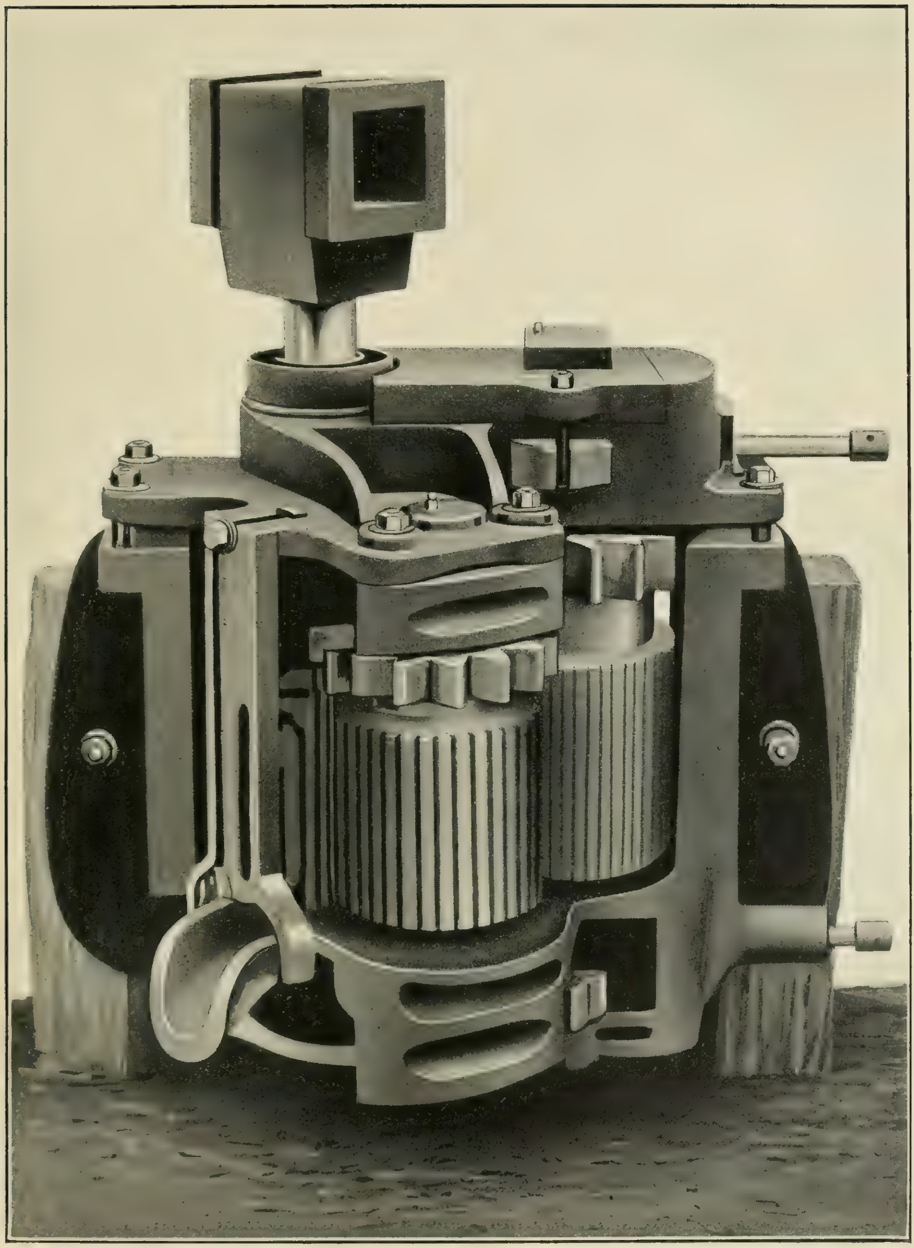
TO ALL intents and purposes, India is a continent rather than a country. It is triangular in shape, with its base resting upon the Himalayas and its apex running far out into the ocean. To the east is the bay of Bengal and to the west the Arabian sea. Its length from north to south and its greatest width from east to west are both about 1900 miles. The Indian empire, including Burma, comprises 1,766,000 square miles, with 294,000,000 inhabitants. It extends from 8 degrees to 37 degrees north latitude, which means from the hottest tropical regions to a point well within the temperate zone, so that it would be idle to attempt to describe here the variety of formation and climate.

In this, the birthplace of sugar cane, accurate information regarding the state of the industry is extremely hard to obtain, for various reasons, among which may be mentioned—

First: In certain portions of the empire very indifferent attention is paid to the compilation of reliable statistics concerning production.

Second: The raising of sugar cane is not carried on by large interests, but is divided among a vast number of small farmers, so that it is doubly difficult to secure dependable data concerning the yield and manufacture.

Third: By no means all of the cane that is grown goes to the sugar mills to be ground. Much of it is chewed or eaten in the stalk, and the manufacturing process itself is, in most instances, very primitive. So it is clear that even where the acreage planted to cane is accurately known, it would be a difficult matter to determine the result in sugar.



SUGAR MILL, NAHAN FACTORY, INDIA

CENTRIFUGAL WORKED BY HAND, INDIA

The area devoted to cane varies year by year and runs between 2,500,000 and 3,000,000 acres, chiefly in the United Provinces, Bengal and the Punjab, although the northwest provinces, Madras, Bombay, central provinces, the Rajput states, and Burma contribute. As the cane-sugar crop of India is estimated to be between 2,225,000 and 2,500,000 tons, it would appear that the sugar realized per acre is something near one ton on an average, as against five and one-half tons in Hawaii. However, there is a good deal of uncertainty regarding the figures, and some authorities consider the total crop very much larger than the amount just mentioned.

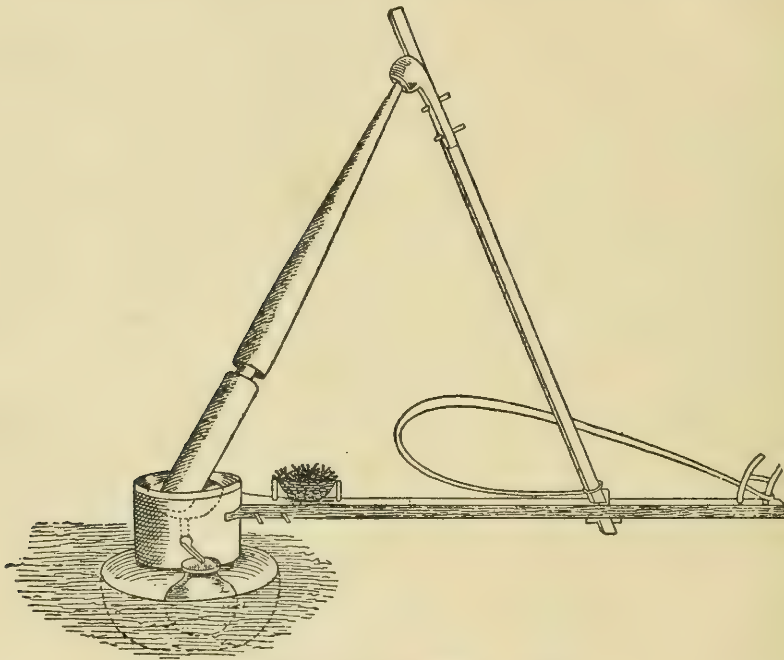
The general practice in India is to plant the cane each year, and ratooning is seldom met with outside of the Poonah district. For fertilization, stable manure, town refuse and crushed oil cake are used. The cane is planted from February to April and harvested from the middle of January to the middle of March of the year following. Water for irrigation purposes is taken from rivers and wells. Climatic conditions are frequently unfavorable. There are long dry spells, the low-lying lands are subject to floods in the rainy season, and in certain sections frost plays havoc with the cane.

Not only was India the original home of sugar cane, but, according to recognized authorities, the secret of preparing sugar from cane juice, which dates from the seventh century, also came from there. Today modern methods are employed to a certain extent, but the original processes predominate, and a word or two concerning the latter will no doubt prove interesting.

The cane is cut into short lengths, placed in a kind of mortar and crushed with a large pestle, worked by oxen. The juice runs through a hole in the side of the mortar into a vessel placed to receive it. The practice in former days was to saw off a good-sized tamarind tree about three feet above the ground

and then scoop out the stump. Later, logs were sunk deep in the ground and hollowed out in the same manner. Stone mortars followed, meeting with great favor, so that the advent of iron roller mills was delayed for many years.

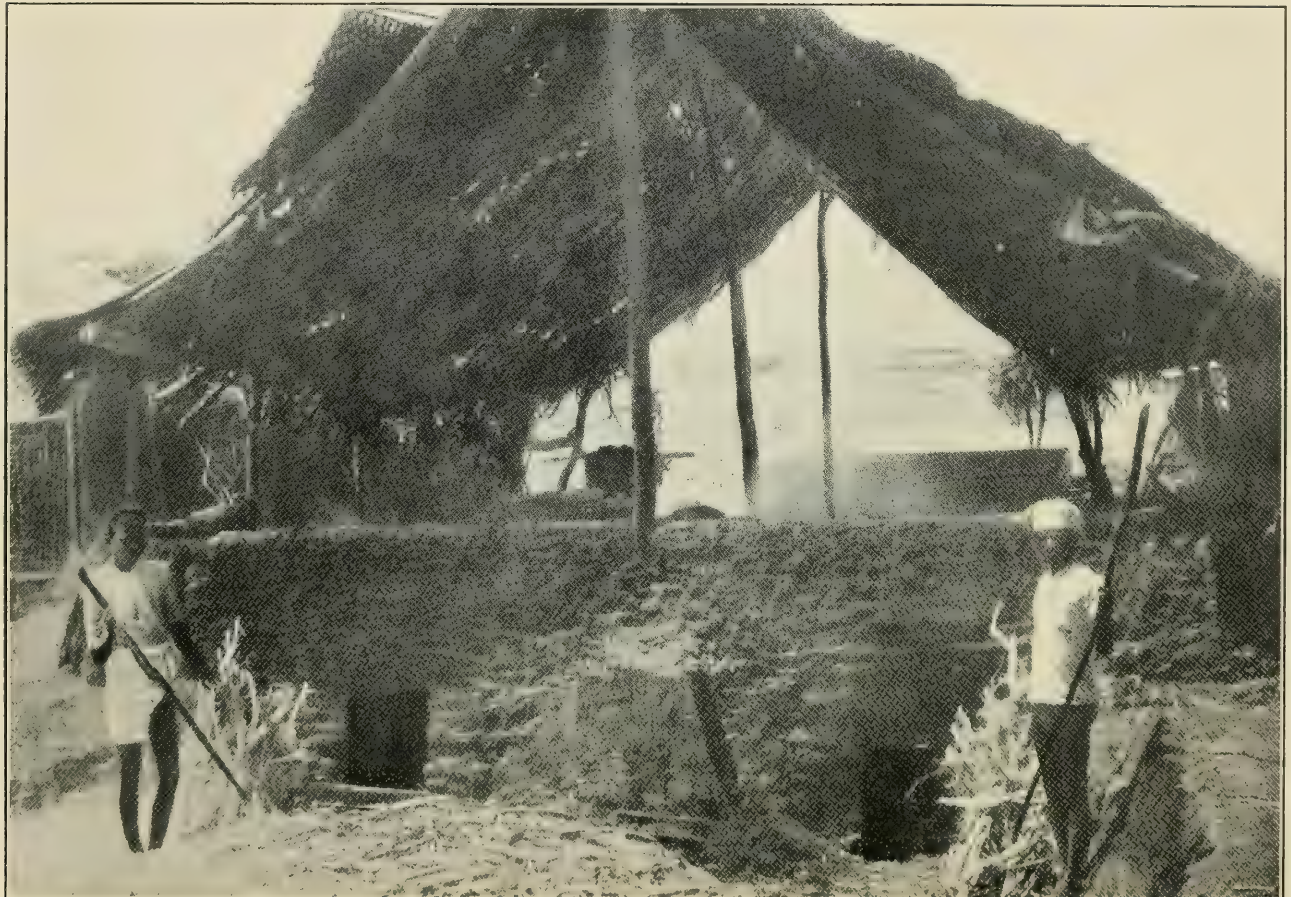
In the mortar-and-pestle operation of cane grinding, the pestle consists of a lever with two arms. The crushing end of



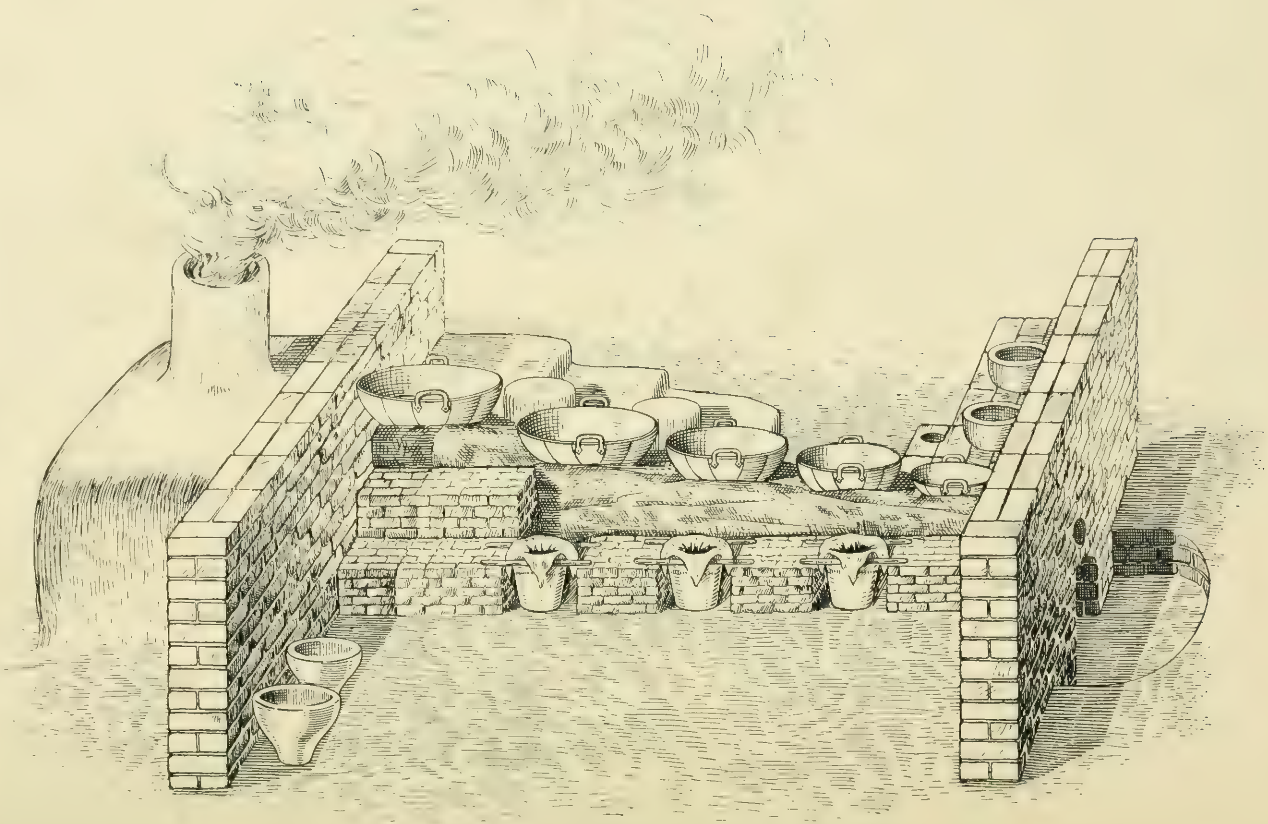
WOODEN MILL FROM GORAKHPUR, INDIA

the principal arm rests on the side of the mortar and the cane is ground between the pestle and the mortar wall. The apparatus is driven by oxen.

This method was improved upon by the introduction of the mill with two-geared wooden rolls set vertically, the core of the taller one projecting upward through a frame and attached to a horizontal lever to which the oxen are harnessed. When the mill is started the cane is fed between the wooden gears and



BOILING BY OLD METHOD, INDIA

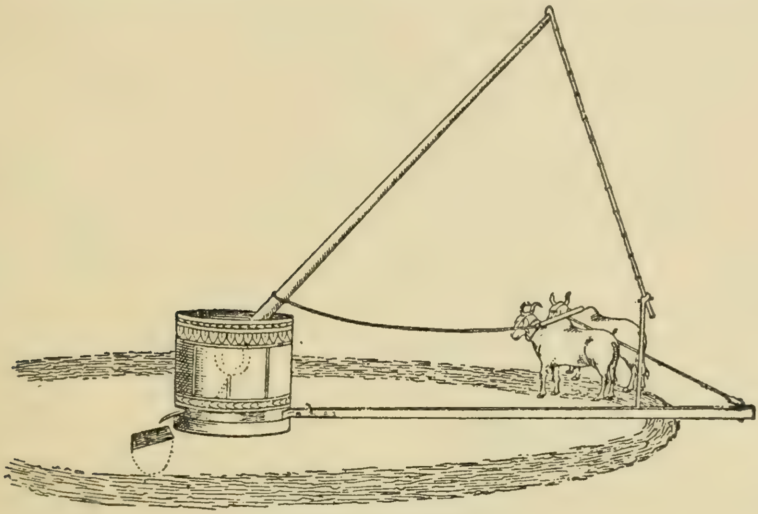


FURNACE AND PANS FOR MAKING RAB, INDIA

the juice expressed in this manner. A further development brought in geared iron cylinders or drums, in sets of two and three. The extraction by these means is extremely poor, ranging from 50 per cent to 62 per cent.

Indian sugar makers treat the cane juice in many ways, but all the various grades or kinds produced come under one of two general heads, ***gur*** or ***rab***.

When making gur the juice is first freed from floating par-



STONE MILL, AGRA, INDIA

ticles of cane by straining. It is then run into a large earthen vessel sunk in the ground. From there it is ladled into smaller pans placed above a furnace, which is a very primitive affair, generally with three pans and having side walls of tiles or brick. Cane trash and bagasse are used as fuel. When the juice in the first pan begins to boil, a thick scum forms on the top and is skimmed off, and this operation is kept up until the liquor becomes clear. It is then taken to the third pan for further boiling and finally concentrated in the second. In many instances purification is limited to skimming, but sometimes this is supple-

mented by adding milk of lime or crude soda ash to the liquor. The scum is set aside to be fed to cattle or very poor people.

When the yellowish-brown mass is boiled to a certain density it is constantly kept in motion by stirring and its consistency is tested at frequent intervals. As soon as it is found that it can be rolled into a ball that upon cooling will remain fairly soft, it is considered sufficiently cooked and the boiling operation comes to an end. Sometimes the hot gur is put into earthen moulds to cool and harden, sometimes it is worked with batons in an earthen vessel and after cooling is made into balls by hand, or flattened out and cut into triangles. The balls and triangles are placed in baskets to dry, after which they are supposed to be ready for consumption. Gur that is soft and of good grain lends itself admirably to the process of refining. Gur that has become solid and hard has to be eaten without further treatment and burnt gur is totally unfit for refining.

Rab is made in nearly the same manner, but with more attention paid to cleanliness. There are five iron pans, which are thoroughly cleansed daily; the skimming and clarifying operations are conducted with more care and the clear juice is filtered through cloth before being concentrated. When the mass of crystals and liquor is found to be of the proper consistency, it is poured into earthen pots to cool and well stirred to help crystallization. This process being finally complete, the moist and somewhat soft sugar can only be removed by breaking the pots containing it. Owing to its almost liquid condition, rab cannot conveniently be transported any distance, so that it is generally used near the place where it is made, chiefly for refining purposes. Gur, on the other hand, being harder, can readily be carried any distance.

Men are sometimes set to work tramping upon sacks filled with rab, in order to separate the syrup from the sugar; again sacks of rab are piled upon a floor with holes for drainage and

SMALL LOCOMOTIVE USED TO DRAW CANE CARS, 2-FOOT GAUGE, INDIA

LOADING CANE CARRIER, MARHOURAH FACTORY, INDIA

a well for the syrup that runs off. Weights are often placed upon the bags in order to hasten the process. After the drainage is fairly complete, the rab is dumped into vessels having openings at the bottom and covered at the top by a layer of wet water plants. The water as it passes through the mass of sugar washes the syrup from the crystals and the liquor runs off through the apertures in the bottom. Several days afterward the operation is repeated, and so on until all the syrup has been removed by washing. The resulting sugar is either used in that form, or dried in the sun and worked by human feet in order to lighten its color.

Saiyid Muhammad Hadi, assistant director of the Land Records and Agriculture at Allahabad, has worked out an improved method for making rab which is now widely adopted. Under his plan the furnace heat can be readily controlled, so that the danger of burning the juices during boiling is considerably lessened; neither is there so much risk of decomposition (souring). Besides, the cooled rab is purged of its syrup in a centrifugal machine worked by hand instead of by drainage from wet vegetation. At best, however, the production of sugar by the natives of Hindustan is still at a very elementary stage, and in that country new ideas gain ground very slowly, so that it will be some time before modern machinery and equipment are generally in use.

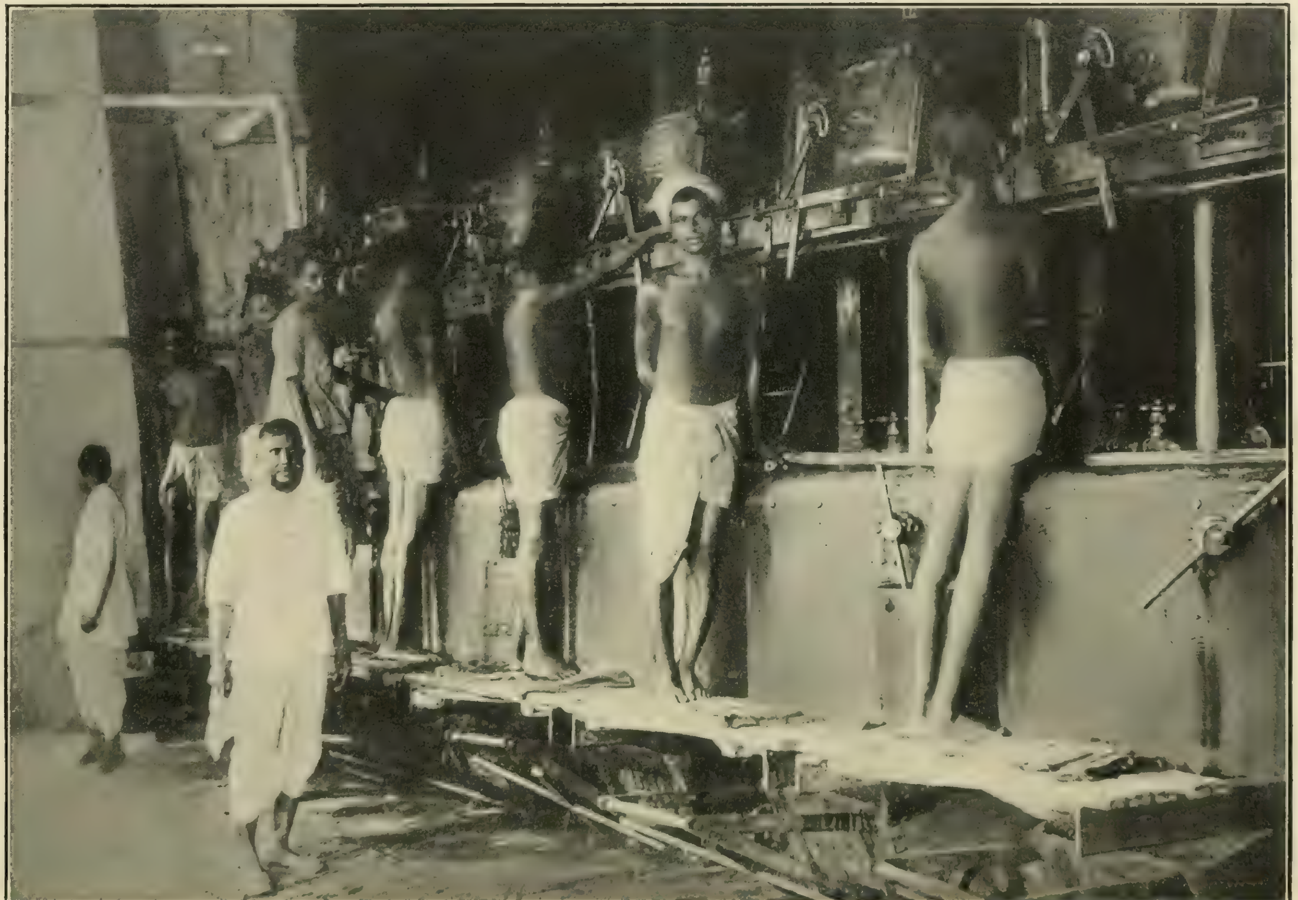
It would seem that in view of the small production of sugar per acre and the enormous losses in manufacture, a modern plant, with machinery of the latest and best type and large financial resources, should be remarkably successful, but such is not the case. It appears to be impossible to get a steady supply of cane. In India, plantations like those found in other countries do not exist. Instead, there are a great number of extremely small pieces of land all under different ownership. The cane has to be brought to the mill from considerable distances

in small quantities, and owing to lack of intelligence or initiative on the part of the farmer it is of indifferent quality. Transportation facilities are far from good and the manufacturers have to make up the shortage in the supply of cane by using rab and gur. If the latter should contain an excessive amount of glucose or be caramelized, it does not lose its value as an article for direct consumption; on the other hand, either of these conditions unfit it for the purposes of refining, and as there is but a slight difference in price between gur and the white sugar into which it is made, the disadvantage to the refiner is readily apparent. Another drawback is that the Hindus do not take kindly to sugar manufactured by the European process, consequently chini, or sugar made from rab by the native method, commands a better price than sugar made in a modern refinery. Religious and caste prejudices exert a strong influence also. In modern sugar refining, animal charcoal is the principal purifying and decolorizing agent, and this, together with the fact that ox-blood has been used for clarification, causes the Hindus to reject sugar prepared by such means. Finally, there is the apprehension on the part of the high-caste natives that the sugar may have been produced by low-caste labor and that to eat it would bring defilement.

The refiners of India have begun to recognize the advantage to them in using raw European beet-root sugars and raw cane from Java and Mauritius instead of the more costly preparations of rab and gur. As a result, there is a considerable quantity of foreign sugar imported into India which is consumed ultimately by the high-caste native without his being aware of its origin.

The imports during the period from 1908 to 1916 were as follows:

| | |
|---|---|
| 1908-09 | 535,664 tons of 2240 lbs. |
| 1909-10 | 556,840 " " " " |



WATER-DRIVEN CENTRIFUGALS, MARHOURAH FACTORY, INDIA

CHAMPARAN SUGAR COMPANY, LTD., BARRAH CHAKIA, CHAMPARAN, INDIA

| | |
|---|---|
| 1910-11 | 608,785 tons of 2240 lbs. |
| 1911-12 | 508,591 " " " " |
| 1912-13 | 675,017 " " " " |
| 1913-14 | 802,978 " " " " |
| 1914-15 | 428,595 " " " " |
| 1915-16 | 515,909 " " " " |

Of this tonnage, Austria supplied the greater amount of the beet, Germany the remainder, while the cane came from Java and Mauritius. In 1913 and 1914 the raw beet from Austria and Germany was almost entirely displaced by washed Java raws, the trade name for which is "Java white." Some sugar is exported, but the quantity is insignificant.

As to the future of the industry in India, the theory is held by many that with modern scientific methods governing cultivation and manufacture, that country would be able not only to provide for its own requirements, but would be a competitor for export trade in the markets of the world. If such a condition is to be brought about, it will not be by improvement in the cane fields and the manufacturing plants alone. There are other problems to be overcome before there can be any great change for the better,—the stubborn opposition of the natives to innovations, the extreme smallness of individual holdings, poverty, lack of initiative and co-operation,—these are the main obstacles in the way of a material increase in the present enormous production, and they will not be easily surmounted.

# CONCLUSION

THE sugar crops of the world for the year 1915-16 aggregated 16,558,863 long tons, of which 10,571,079 tons were cane. The following table shows the production of the various countries:

| | TONS |
|---|---|
| **NORTH AMERICA** | |
| United States | |
| Hawaii | 545,000 |
| Louisiana | 122,768 |
| Texas | 1,000 |
| Porto Rico | 400,000 |
| Cuba | 3,000,000 |
| British West Indies | |
| Trinidad | 55,000 |
| Barbados | 50,000 |
| Jamaica | 15,000 |
| Other British West Indies | 30,000 |
| French West Indies | |
| Martinique | 40,000 |
| Guadeloupe | 40,000 |
| Danish West Indies | |
| St. Croix | 11,000 |
| Santo Domingo | 120,000 |
| Mexico | 75,000 |
| Central America | 30,000 |
| **SOUTH AMERICA** | |
| British Guiana | 110,000 |
| Surinam | 13,000 |

| | TONS |
|---|---|
| Venezuela | 10,000 |
| Peru | 200,000 |
| Argentina | 155,000 |
| Brazil | 194,000 |
| TOTAL IN AMERICA | 5,216,768 |
| **ASIA** | |
| British India | 2,636,875 |
| Java | 1,264,000 |
| Formosa | 391,549 |
| Philippine islands | 300,000 |
| TOTAL IN ASIA | 4,592,424 |
| **AUSTRALIA AND POLYNESIA** | |
| Queensland, New South Wales | 150,000 |
| Fiji | 90,000 |
| TOTAL IN AUSTRALIA AND POLYNESIA | 240,000 |
| **AFRICA** | |
| Egypt | 110,000 |
| Mauritius | 215,528 |
| Réunion | 40,000 |
| Natal | 100,000 |
| Mozambique | 50,000 |
| TOTAL IN AFRICA | 515,528 |
| **EUROPE** | |
| Spain | 6,359 |
| TOTAL CANE SUGAR | 10,571,079 |
| **BEET SUGAR** | |
| Europe | 5,190,387 |
| United States | 779,756 |
| Canada | 17,641 |
| TOTAL BEET SUGAR | 5,987,784 |
| GRAND TOTAL CANE AND BEET SUGAR | 16,558,863 |

From the time when the soldiers of Alexander of Macedon found sugar cane in India, over three hundred years before the Christian era, knowledge of sugar and its cultivation has accompanied great political movements.

In the sweep of the Saracen conquest from Persia to Egypt and on through northern Africa into Spain, sugar followed the footsteps of the invading armies. The Crusaders brought it with them when they returned home from Palestine. Daring Portuguese adventurers carried it to the Madeiras, the Azores, the Cape Verde and other islands of the east Atlantic ocean when they captured and colonized them in the fifteenth century. The New world received sugar cane at the hands of Christopher Columbus, who planted it in Santo Domingo in 1493. Shortly after Pizarro's first landing it was brought to Peru by the Spanish conquerors. Cortés himself introduced it in Mexico, erecting the first mill there in 1520; and when, during the struggle between Great Britain and France, sugar was excluded from Europe by the blockading British fleet, it was Napoleon Bonaparte who called beet-sugar manufacture into being.

Before the outbreak of the great war in 1914, the world's crops of sugar were pretty evenly divided between cane and beet, with a preponderance in favor of the former. How this titanic conflict has affected the European production is clearly seen by the returns for 1915-16. During that season the world's output was 16,558,863 long tons, made up of 10,571,079 tons of cane and 5,987,784 tons of beet, and Europe was short 2,392,828 tons as compared with the previous year. The conclusion is inevitable that after the war shall be brought to an end a period of poverty and distress will ensue and restriction of sugar consumption in Europe will be one of the results of this condition.

Apart from countries where sugar production is fostered by protecting tariffs, it seems certain that future development and

progress will take place in lands where favorable climate, rich soil and adequate, cheap labor are found together. The natural economic law will cause the industry to thrive best where such conditions obtain in the fullest degree, and to fall off correspondingly as they diminish.